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SEATIDE

SEATIDE ANALYSIS PROCESS

VOLUME IIIA

CRUISE MISSILE — CONCEPT GENERATION AND SCREENING MODEL (CM-CGSM)

USERS MANUAL

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JAN 13 1978

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VOUGHT SYSTEMS DIVISION
LTV AEROSPACE CORPORATION

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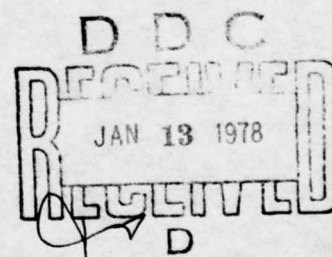
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SEATIDE ANALYSIS PROCESS.

VOLUME IIIA.

CRUISE MISSILE — CONCEPT GENERATION AND SCREENING MODEL (CM-CGSM).

USERS MANUAL. Revision A.

408 116

FOREWORD

(U) This report was prepared by the Vought Systems Division, LTV Aerospace Corporation, P.O. Box 6267, Dallas, Texas 75222 under U. S. Army Electronics Command Contract DAAB09-72-C-0062. The work was initiated under the direction of Captain R. A. Dowd, USN and completed under Captain W. A. Greene, USN, Chief, Long Range Forecast Division, Directorate of Estimates, Defense Intelligence Agency (DIA-DE-1).

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TITLE: SEATIDE ANALYSIS PROCESS - VOL. IIIA

REPORT NO. 00.1636

REVISION A

INSTRUCTIONS:

Pages to be removed:	Pages to be inserted:
Title page through ii	Title page through ii
iii through x	iii through x
II-13 through II-16	II-13 through II-16
III-1 through III-77	III-1 through III-141
IV-11 through IV-16	IV-11 through IV-16
V-1 through V-25	V-1 through V-8
VII-1 through VII-27	VII-1 through VII-40

(U) This report has been prepared in the following volumes:

Volume	Classification	Title
I	S	Summary
IIA	U	Naval Engagement Model (NEM) - Users Manual
IIB	U	NEM - Appendices A - I
IIC	S	NEM - Appendices J - M
IID	U	NEM - Appendix N
IIIA	U	Cruise Missile - Concept Generation and Screening Model (CM-CGSM) - Users Manual
IIIB	U	CM-CGSM Appendices A-B
IIIC	S	CM-CGSM Appendix C
IIID	U	CM-CGSM Appendices D-G
IIIE	U	CM-CGSM Appendix H
IV	S	Relative Worth Model (RWM)
V	U	Relative Cost Model (RCM)

ABSTRACT

The SEATIDE Analysis Process is a semi-automated procedure for the generation of time-phased, high value cruise missile weapon systems concepts, together with the supporting technology and intelligence indicators which would reflect that these technological goals are being achieved. The SEATIDE process can also be used to evaluate the effectiveness of fixed force levels, existing forces in SAL environments, or Naval defenses.

The Defense Intelligence Agency, through its Directorate of Estimates, and The Advanced Research Projects Agency (ARPA) have sponsored the development of this computer based analysis at the weapon system and Naval force structure level. A previous process, RIPTIDE, was developed for DIA for use in analysis of strategic missile systems.

Generic to the SEATIDE Analysis Process are three major computer models: The Naval Engagement Model (NEM), Cruise Missile Concept Generation and Screening Model (CM-CGSM) and Relative Worth Model (RWM). The NEM evaluates force effectiveness, tactics, and task force configurations; the CM-CGSM enables definition and selection of candidate, advanced cruise missile system concepts; and the RWM permits assessment of worth in accordance with a variety of objective and subjective criteria. Each of these models has been checked out by DIA.

In addition to exercising the computer models, there are several other analytical and engineering tasks to be performed, e.g., the identification of areas of current interest and the associated criteria and potential concepts, the creation of a foreign technology data bank in a format needed by the computer models, the engineering of concepts to the required detail, and the use of a verification analysis loop.

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CRUISE MISSILE - CONCEPT GENERATION AND SCREENING MODEL (CM-CGSM)

APPENDICES

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VOLUME IIIA

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS
(Continued)

3.   CGSM TØP LEVEL FLØW

The CGSM top level flow is diagrammed in Figure II-10. The use and functional steps of the CGSM are as follows:

(a)   The user selects sets of basic variables and NAMELIST constants defining the payload, wings, tails, inlets, airframe, propulsion system, and trajectory profile.

(b)   Baseline worth and worth derivatives are computed from output of the Naval Engagement Model (NEM) and are input along with the data in (a).

(c)   The CGSM sizes, designs, and packages the propulsion systems, payload, aerodynamics, and control surfaces to determine concept total weight. The model then flies the missile through the required trajectory profile to compute its overall range and cruise range. Next the CGSM logic computes relative worth of the concept.

(d)   The CGSM stores selected data for each concept as it is generated, and retrieves those data during the screening step. The model screens all concepts to dominance levels using relative worth versus relative cost.

During the CGSM generation steps, all basic variables, and furthermore, all candidate concepts which pass certain built-in performance and sizing constraints, are considered to be of equal credibility. However, the CGSM method of using all permutations of the basic variables set may result in some mismatches of design or performance parameters; that is, may result in some non-optimum configurations. There is, then, a need to screen the generated configurations and isolate those which dominate, or which best satisfy mission and design objectives.

FIGURE II-10   CGSM TOP LEVEL FLOW

START → READ INPUT DATA → (1) SELECT BASIC VARIABLE SET → COMPUTE PAYLOAD WEIGHT, WING WEIGHT, TAIL WEIGHT, AND ALLOWABLE PROPULSION SYSTEM WEIGHT → SIZE BOOSTER TO AN IDEAL VELOCITY → (2)

(2) → SIZE SUSTAINER TO THE WEIGHT (OR LENGTH) AVAILABLE. SIZE SUSTAINER FIXED WEIGHTS FIRST AND THEN ADD FUEL UP TO THE LIMITING WEIGHT OR LENGTH. → COMPUTE AERODYNAMICS DATA TABLES (CD vs MACH NO. AND ALTITUDE. AND LIFT CURVE SLOPE vs. MACH NO.) → FLY MISSILE TRAJECTORY PHASE BY PHASE. COMPUTE MAXIMUM RANGE BY VARYING CRUISE PHASE LENGTH UNTIL PROPELLANT IS EXHAUSTED. → TEST LAUNCHER PACKAGING, COMPUTE WORTH, AND STORE DATA FOR SCREENING → (1)

(3) → ALL BASIC VARIABLES USED?
NO → (1)
YES → EXIT
→ SCREEN CONCEPTS AND OUTPUT DETAILED DATA FOR HIGH LEVEL CONCEPTS → EXIT

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3.1 Executive Methodology

The CGSM executive logic links together the major design, sizing, and performance models by coordinating all their input, output, and internal communication requirements. The executive includes many special purpose steps such as worth/cost/screening operations, basic variable selection logic, and booster ΔV iteration logic steps.

3.2 Cost and Worth Methodology

The Naval Engagement Model (NEM; see Volume IIA) computes Red versus Blue kill for selected scenarios. The CGSM user reduces the kill data to baseline worth and to tables of worth with respect to cruise missile design/performance parameters. CGSM worth parameters include accuracy (CEP), maximum range, force size, flight reliability, warhead weight, cruise phase range/altitude/velocity, and run-in phase range/altitude/velocity. Worth for each generated missile concept is computed in the WORTH module using the relationship:

$$W_{CONCEPT} = W_{BASELINE} + \sum_{i=1}^{6} \Delta W_i$$

where ΔW_i is the change in worth with respect to the ith parameter. This "relative" worth is computed for each missile during concept generation and is used to screen the various configurations.

Relative cost of each missile concept is computed in the Relative Cost Model (RCM). The RCM computes RDT&E cost, first unit production cost, and total cost.

Concept screening is executed by the SØRTCM module in terms of relative worth versus cruise missile cost. Concepts are sorted into dominance levels and are arranged in order of increasing cost within a given level.

3.3   AERODYNAMICS METHODOLOGY

The Aerodynamics Model is designed to provide the aerodynamic parameters required by the CGSM for the general solution to the cruise missile synthesis problem. The coefficients required for performance analysis (C_L, C_D) are the primary output; however, certain elements of the pitch and roll characteristics of the configuration are also computed in the model. Basic force coefficients and pitch plane aerodynamic derivatives are computed as a function of vehicle geometry, flight conditions, and center of gravity location. Force coefficients (C_L, C_D) are required for mission performance analyses in the Vehicle Performance Model.

The model computes aerodynamic coefficients of each element of the configuration and combines these elements along with appropriate interference factors into a description of the complete configuration aerodynamics. Component drag coefficient is computed as a function of both Mach number and altitude, because of the dependency of skin friction drag on altitude, while curve slope is computed as a function of Mach number only. The general procedure for this is diagrammed in Figure II-11. The analysis is limited to the linear angle-of-attack region, to Mach numbers from 0 to 5.0, and to altitudes below 100,000 feet. Component drag is compiled from skin friction drag, nose pressure drag, afterbody pressure drag, base drag, wing/tail/inlet drag, and induced drag. Lift is compiled from nose and cylindrical section lift, boattail lift, wing/ tail lift, and inlet lift.

SECTION III

CGSM INPUTS

1.0 INPUT DATA DESCRIPTION

Input to the CGSM consists of a punched-card deck containing a mixture of formatted data tables and NAMELIST lists. This section discusses each table and NAMELIST list, defines all list/table items, and discusses list options and applications.

Formatted input falls into two types. A formatted "basic variables" table is provided to allow synthesis of multiple missile designs in a given CGSM case. As few as 1 or as many as 16 values can be input through that table for as many as 17 basic variables, and a missile will be synthesized for each permutation of the sets. If a single value is input for each basic variable, the CGSM will synthesize a single missile for each case. Basic variables are useful in generating data for trend analysis. A second type of formatted data input is provided for convenience in loading ramjet inlet maps and ramjet fuel decks. Those data tables may be loaded as NAMELIST data (see Section 3.10) below or as formatted decks.

NAMELIST input to the CGSM is grouped according to function to reduce the size and complexity of the data deck. NAMELIST input variables have prestored values which will be used unless the variables are referenced in the input deck. A supervisory NAMELIST (SUPER) is provided to ease input requirements for stacked cases. That list contains a number of frequently-changed variables from all synthesis specialty areas.

The CGSM executive is programmed to accept the data tables and NAMELIST lists in any order within the card input deck for a given case. That self-loading feature is based on input of a unique "ZIP code" control card with each table or list. That ZIP code is tested in the executive and used to route to the READ statements required for each table or NAMELIST. The complete set of ZIP codes is presented and defined in Figure III-1. The cards are formatted as follows:

FIGURE III-1

ZIP CONTROL CARDS

1 2 3	4	5 6	7	8	9 10	11 12 13 14 15 16 17 18 19 20	
ZIP		1					READ SECURITY & LABELING CARDS & SET NPAGE=1
ZIP		2					PRINT HEADER PAGE
ZIP		4	1				READ I/O CONTROL LIST (NAM1)
ZIP		4	5				READ BYPASS LIST (NAMBYP)
ZIP		4	8				READ CONFIGURATION OPTION LIST (NAMCNF)
ZIP		4	9				READ PACKAGING LIST (NAMPAK)
ZIP		5	8				READ GENERAL BOOSTER LIST (NAMBOO)
ZIP		5	8		1		READ EXTERNAL BOOSTER TERMS (NAMEXB)
ZIP		5	11				READ SOLID ROCKET SUSTAINER LIST (NAMSR)
ZIP		5	12				READ LIQUID ROCKET SUSTAINER LIST (NAMLR)
ZIP		6	1				READ RAMJET SUSTAINER LIST (NAMRJS)

FIGURE III-1 (CONTINUED)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Z	I	P			6	6	5	7											O	READ R/J TEMP. RISE TABLE WITH NAMTRS
Z	I	P			6	6	5	7											1	READ R/J TEMP. RISE TABLE FORMATTED DECK
Z	I	P			6	6	5	8											O	READ R/J SPECIFIC HEAT TABLE WITH NAMSPH
Z	I	P			6	6	5	8											1	READ R/J SPECIFIC HEAT TABLE FORMATTED DECK
Z	I	P			6	6	5	9											O	READ R/J GAS CONSTANT TABLE WITH NAMGSC
Z	I	P			6	6	5	9											1	READ R/J GAS CONSTANT TABLE FORMATTED DECK
Z	I	P			6	6	6	1												READ INLET SIZING & PERFORMANCE DATA WITH NAMINM
Z	I	P			6	6	6	2												READ INLET SIZING DATA WITH NAMINM & THEN PERFORMANCE DATA WITH FORMATTED DECK
Z	I	P			6	6	6	0												READ R/J BURNER SEVERITY DATA WITH NAMBSP
Z	I	P			6		8													READ TURBOJET SUSTAINER LIST (ANMTJ)
Z	I	P			6	1	5												N	READ TRAJECTORY CONTROL DATA FOR TRAJECTORY NO. N, WHERE N = 1, 2, 3, 4, 5
Z	I	P			7	4	1													READ BASIC VARIABLES TABLE

III-3

FIGURE III-1 (CONTINUED)

1 2 3 4	5 6	7 8	9 10	11 12 13 14 15 16 17 18 19 20	
ZIP	8	1			READ RCM CER COEFFICIENTS (NAMCNP)
ZIP	8	2			READ RCM CER COEFFICIENTS (NAMCCN)
ZIP	8	3			READ RCM CER COEFFICIENTS (NAMCPS)
ZIP	8	4			READ RCM CER COEFFICIENTS (NAMCCP)
ZIP	8	5			READ RCM BYPASS DATA (NAMCBY)
ZIP	8	6			READ COST DATA (NAMCST)
ZIP	9	3			READ WORTH DATA (NAM3)
ZIP	11	1			READ COMPATIBILITY MATRIX, SUPER NAMELIST, AND GO SYNTHESIZE MISSILES
ZIP	11	1	1		READ SUPER NAMELIST AND GO SYNTHESIZE MISSILES
ZIP	11	3			READ NAMSCR NAMELIST AND SCREEN
ZIP	11	4			BYPASS CONCEPT GENERATION AND COMPUTE COST IN THE RCM DIRECTLY FROM NAMCBY DATA

Column	Parameter
1-4	"ZIP" must be punched in columns 1-3 with column 4 blank (A4).
5-10	These columns contain the actual ZIP code (3I2).
11-20	Auxiliary control variable used to control input of inlet and fuel decks (I10).
21-40	Specialized control parameters not used in the CGSM (4I5).
41-80	Optional comment space (10A4).

Labeling and classification cards are provided as input for each case. The classification card is used to input a message which is printed at the top and bottom of each page of printed output. The labeling card is used to input a message which is printed at the top of each page of printed output. Those cards have the following format:

Column	Parameter
1	Blank (1X)
2-80	Classification or labeling message (19A4, A3)

During CGSM execution, functions assigned to a specific ZIP code are initiated as soon as that ZIP card is executed, and those are completed before another ZIP card is considered. The sequence of ZIP and data cards, then, determines the order of execution of the problem. A typical data deck is illustrated on Figure III-2, and contains the following card sets:

Set A   The first card of each data deck is always a security classification card. Data punched in the 80 columns of this card are printed at the top and bottom center of each printed output page during execution. This card must also follow each ZIP 1 card.

Set B   The second card of each data deck is called the PCODE card and is used to label the problem. Data punched in the 80 columns of this card are printed at the top of each printed output page during execution. The PCODE card is also updated after each ZIP 1 command. If columns 1 through 4 are left blank, the card image print of the input deck is suppressed.

FIGURE III-2

CGSM DATA DECK SETUP

G — ZIP 10 (STOP CARD)

F — INPUT FOR
OTHER CASES

E — NAMSCR NAMELIST CARDS

SCREENING ZIP CARD

D — SUPER NAMELIST CARDS

D — CONCEPT GENERATION ZIP CARD

C — NAMELIST LISTS AND
BORDERED TABLES
FOR THIS MODEL

B — JOB LABEL (PCODE) CARD

A — CLASSIFICATION CARD
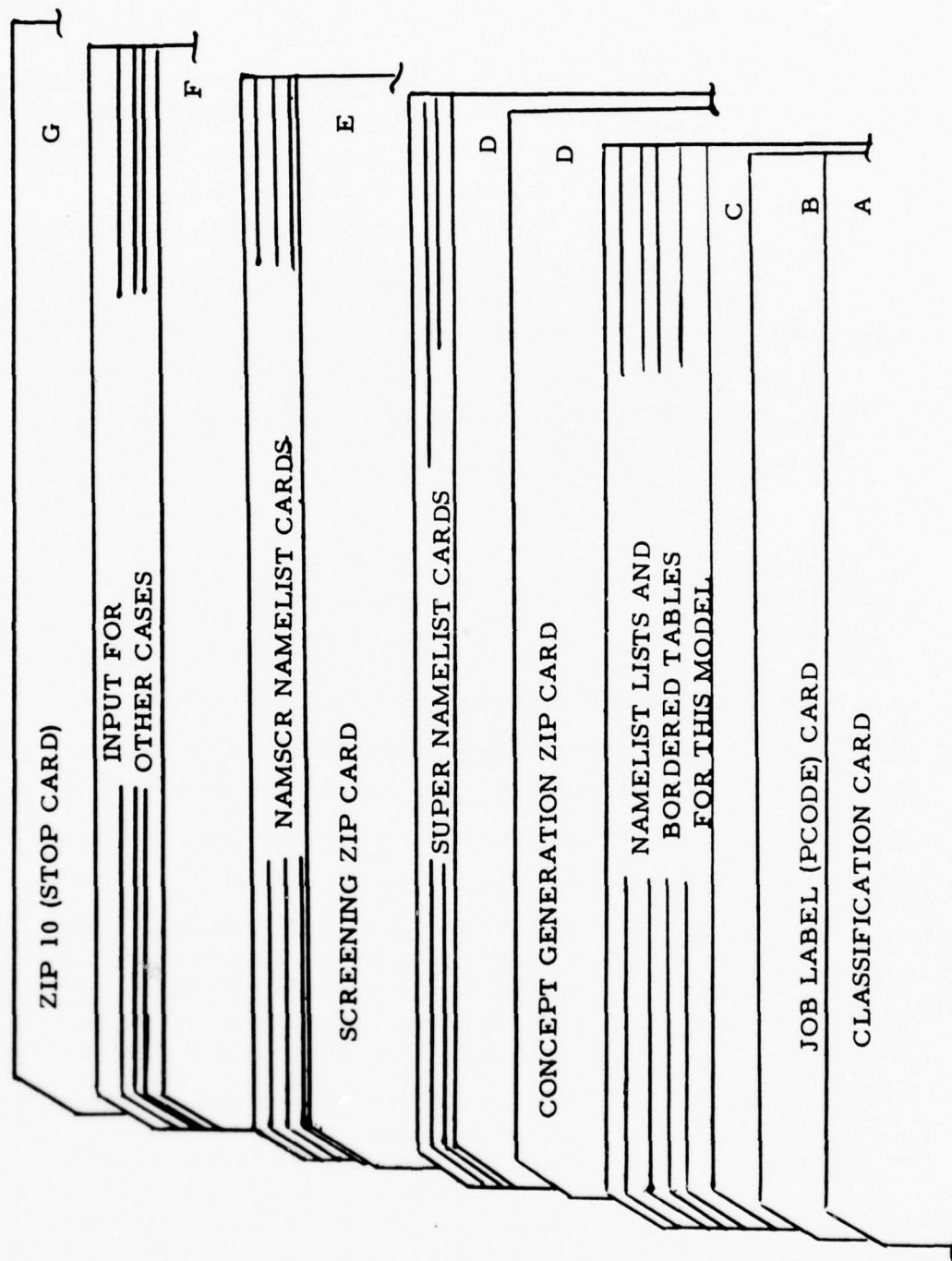
Set C   The third and succeeding cards of the data deck
             include all NAMELIST input lists (except SUPER),
             a basic variables list, and tabular data. Each
             input data list must be preceeded by its appropriate
             ZIP code card. The order in which these lists are
             input may be varied.

Set D   A single ZIP card followed by the SUPER NAMELIST
             list initiates concept generation. A compatibility
             matrix may be inserted after the ZIP card but
             before SUPER.

Set E   A single ZIP card followed by the NAMSCR NAMELIST
             list initiates concept screening.

Set F   Multiple cases may be executed in a single problem.
             Card sets C through E are repeated for each case
             as required. Cards A and B are also required if a
             ZIP 1 is used.

Set G   A ZIP 10 card terminates the JØB when all problems
             are completed.

All tables and NAMELIST lists are defined in this section. A basic variables
table and SUPER NAMELIST are required for all cases, regardless of the
availability of prestored data. All other lists are required only if their pre-
stored data are unacceptable. Certain lists are required only if specialized
options are requested.

Input requirements are heavily dependent on propulsion system
type. Available sustainer types, and optional boosters available for each
sustainer, are shown on Figure III-3.

Liquid and solid rocket sustainer fuel data may be changed, to
accommodate a change in fuel type, by reprogramming and recompiling
a set of BLØCK DATA modules. Instructions for BLOCK DATA repro-
gramming are found in Section 4.

FIGURE III-3

BOOSTER/SUSTAINER AVAILABILITY

SUSTAINER OPTION	FIXED WEIGHT		FIXED LENGTH	
	NO BOOSTER	WITH BOOSTER	NO BOOSTER	WITH BOOSTER
RAMJET	Yes	Yes (Integral or External)	Yes	Yes (Integral or External)
LIQUID ROCKET	Yes	Yes (External)	Yes	No
SOLID ROCKET	Yes	Yes (External)	Yes	No
TURBOJET	Yes	Yes (External)	No	No

2.0   BASIC VARIABLES INPUT

Multiple missiles are synthesized during a single CGSM case through input of multiple basic variables. A total of 17 basic variables are provided, and each may be assigned up to 16 values. Basic variables are input through a specialized table format which is described in this section. Missiles are normally synthesized using all permutations of the basic variable values; however, selected permutations may be excluded through input of a compatibility matrix. That matrix and its tabular format are also described in this section.

The basic variables table and its compatibility matrix are described with the aid of sample input lists. Those lists are written on 80-column format paper, and are appended to the figures defining table variables. No prestored values are available for basic variables; however, compatibility matrices are prestored in such a way as to allow all basic variable permutations to be synthesized. Format specifications are listed for each card of each table. Those specifications, along with the 80-column illustrations, are the basis for assembling table data decks. Three FORMAT types are used as follows:

(1)   "A" FORMAT is used to input alphameric labeling data and comments. Multiples of A4 are used for large fields. Any of the A formatted fields on a basic table input card may be left blank; however, each card, even if left completely blank, must appear in the input deck.

(2)   "I" FORMAT is used to input integer numbers. All such integers are assumed to be right - justified in their field, and blanks are interpreted as zeros.

(3)   "F" FORMAT is used to input floating point numbers. Multiples of F10.0 are generally used. Numbers may be punched in any column of their field as long as a decimal point is used.

2.1 BASIC VARIABLES TABLE

A total of 17 basic variables are provided, and each is dimensioned for as many as 16 values. The basic variable list contains exclusively design and sizing parameters. Since the sizing methodology covers numerous configuration and propulsion system types, the basic variables list necessarily must cover those types as well. The 17 variables thus may define different parameters corresponding to the unique selection of types for each job. A list of available basic variables, their definitions, and their input card formats, is included as Figure III-4. A sample table, laid out on 80-column format paper, is a part of that figure. The sample table is assembled for a typical ramjet missile synthesis job.

The basic variables table is loaded with a ZIP code of "ZIP 7 4 1" (see Card A on Figure III-4). The first card following the ZIP card must be a table number card. That second card contains only two input variables plus labeling space (see Card B on Figure III-4). The two required inputs are a table number (always set to 2010000) and the parameter "m" (maximum number of table entries allowed for a single basic variable). The parameter, m, is used to control the reading of the column label cards and basic variable cards. If $m \leq 6$, one label card and one card for each of the 17 basic variables is expected by the CGSM executive. If $6 < m \leq 12$, two cards are expected for column labeling and two each for the basic variables. If $12 < m \leq 16$, three cards each are expected for the column labels and basic variables. If fewer than m values are required for any of the basic variables, blank entries (or blank cards) must be used. The table identifier card is followed by the column labeling card (or cards if $m > 6$). Format of that card is defined and illustrated in the two parts of Figure III-4 (see Card C).

Basic variables are defined, and their formats are illustrated, in Figure III-4 under Card D (cards D1, D2,...,D17). Options available within that list are described on that figure. Columns 1 - 16

FIGURE III-4

CGSM INPUT - BASIC VARIABLES

```
ZIP  7 4 1
```

TABLE NO. 2010000

READ BASIC VARIABLES TABLE

NO. VARIABLE	NO.	VALUE 1	VALUE 2	VALUE 3	
			3		A
					B
					C
1. WING AREA	1	0.0			D1
2. TAIL AREA	1	3.348			D2
3. W.ASPECT.R	1	0.0			D3
4. P/L LENGTH	1	177.5			D4
5. W/H WEIGHT	1	180.6			D5
6. C WEIGHT	1	226.0			D6
7. DIAMETER	3	18.0	19.0	20.0	D7
8. BOOSTER T/W	1	15.0			D8
9. D.P. ALT	1	3000.0			D9
10. D.P. MACT	1	2.5			D10
11. D.P. GAMMA	1	30.0			D11
12. D.P. TTY	1	3800.0			D12
13. D.P. F.CONS	1	0.0			D13
14. D.P. N.ACC.	1	0.0			D14
15. D.P. T.ACC.	1	0.8			D15
16. D.P. PCMGN	1	3.0			D16
17. MISSILE WT.	3	3500.0	3750.0	4000.0	D17
TABLE TYPE					E
CONSTANTS					F
					G

III-11

Figure III-4   (Cont'd.)

CARD   DEFINITION

A   ZIP code card. Format includes:

             Column   Parameter

             1 - 4   ZIP designator (A4)

             5 - 10   ZIP number (3I2)

             11 - 40   Not used (I10, 4I5)

             41 - 80   Optional comment space (10A4)

B   Table identifier card. Format includes:

             Column   Parameter

             1 - 12   Optional comment space (3A4)

             14 - 20   Table no. 2010000 (I7)

             21 - 30   Not used (2I5)

             31 - 35   Case number (user optional) (I5)

             36 - 40   Maximum number of table entries allowed
                      for a single basic variable (m) (I5)

             41 - 80   Optional comment space (10A4)

C   Column labeling instructions. Format is specified as
             follows:

             FØRMAT (5A4, 6 (2X, 2A4))

             A second card is required if $m > 6$, and a third if
             $m > 12$, using

             FØRMAT (20X, 6 (2X, 2A4))

             Card C is required even if the fields are left blank.

*D   Basic variables cards. Format includes:

             Column   Parameter

             1 - 16   Optional comment space   (4A4)

             17 - 20   Number of values input   (I4)

             21 - 80   Basic variable values   (6F10.0)

             A second card is required for each basic variable if
             $m > 6$, and a third card if $m > 12$. Those cards use the
             format:

Figure III-4 (Cont'd.)

VARIABLE   DEFINITION

Column	Parameter
1 - 20	Not used (4A4, I4)
21 - 80	Basic variable values (6F10.0)

E - G   These cards are required to close out the table. Insert
             them as shown in the illustration.

- - - - - - - - - - - - - - - - - - -

* The following are basic variables:

CARD	BASIC VARIABLE
D1	Total exposed wing area in sq. ft.
D2	Total exposed (all panels) tail area in sq. ft.
D3	Wing aspect ratio (exposed span)^2/(exposed area)
D4	Payload compartment length in inches
D5	Warhead weight in lb.
D6	Controls system weight in lb.
D7	Missile airframe diameter in inches
D8	Booster delivered thrust-to-weight ratio

D9   Propulsion parameter no. 1

    = Maximum thrust for liquid or solid rockets if
ITHR=0 in SUPER (lb)

    = Maximum thrust-to-weight ratio for solid or liquid
rockets if ITHR=1 in SUPER

    = Design point altitude for ramjets or turbojets (ft)

D10   Second propulsion parameter

    = Specific impulse (at maximum thrust) for liquid or
solid rockets (sec)

    = Design Mach number for ramjets or turbojets

D11   Third propulsion parameter

    = Chamber pressure for liquid or solid rocket (psi)
    = Design point flight path angle for ramjets (deg)
    = Design maximum thrust (sea level static) for
turbojets (lb)

Figure III-4 (Cont'd.)

CARD   BASIC VARIABLE

D12   Fourth propulsion parameter

              =   Liquid fuel mixture ratio for liquid rockets (set to one for solid rockets)

              =   Combustion temperature (TT4) for ramjets (°R)

              =   Turbine inlet temperature for turbojets (°R)

D13   Propulsion design parameter number 5 (ramjets only)

              =   Fraction of ramjet fuel consumed at the design point

D14   Sixth propulsion parameter (ramjets only)

              =   Ramjet design point normal acceleration component (g)

D15   Seventh propulsion parameter (ramjets only)

              =   Ramjet design point tangential acceleration component (g)

D16   Eighth propulsion parameter (ramjets only)

              =   Ramjet design pressure margin

D17   Sizing parameter

              =   Missile total weight if INWØRL=0 in SUPER (lb)

              =   Missile total length in INWØRL=1 in SUPER (in)

are reserved for optional numbering, labeling, and comments. The number of values entered for a given basic variable (n_i) is entered in columns 17 - 20 on the first card input for that variable. Each basic variable may be assigned a number of entries which is independent of any other basic variable, and is only limited to be less than or equal to the maximum (m) entered on Card B. The values that a given basic variable will assume during missile synthesis are entered in columns 21 - 80 on one, two, or three cards, depending on the value of m. If n_i is less than m, the fields corresponding to n_{i+1}, n_{i+2}, ... m are left blank.

The structure and format of the basic variable table is invariant, in that all 17 variables must be input for every job, and a set number of cards is loaded for each variable even if n_i < m. The values loaded through a particular variable are subject to user options, however. Those options are described briefly in the following paragraphs.

Missiles may be synthesized with wings and/or tails or with no wings and/or tails using control options provided under the NAMELIST lists NAMCNF (Figure III-13) and SUPER (Figure III-29). If a job calls for synthesis of a wingless missile, single values of zero are input for basic variables 1 and 3. If the missile has no tail, basic variable no. 2 should have a single input of zero.

Non-boosted missiles may be synthesized by proper selection of the parameter KPRØP in the SUPER list (Figure III-29). In that event, basic variable no. 8 (booster thrust-to-weight ratio) is input with a single, dummy value of zero.

Basic variables 9 through 16 are dependent on sustainer type (see also KPRØP in the SUPER list). Settings of those variables for the various types are as follows:

(1)   Solid Rocket Sustainer - Sustainer maximum thrust,
        specific impulse, and chamber pressure are input
        through variables 9, 10, and 11, respectively.
        Variable 9 may be maximum thrust-to-weight ratio
        (if ITHR=1 in SUPER). Variables 12 through 16 are
        input with dummy values.

(2)   Liquid Rocket Sustainer - Sustainer maximum thrust,
        specific impulse, chamber pressure, and fuel mixture
        ratio are input through variables 9 through 12.
        Variable number 9 is taken to be maximum thrust/
        weight if ITHR=1 in SUPER. Variables 13 through 16
        are input with dummy values.

(3)   Ramjet Sustainer - Design point altitude, Mach
        number, flight path angle, combustion temperature,
        fuel consumed fraction, normal acceleration, tangen-
        tial acceleration, and pressure margin are input
        through variables 9 through 16.

(4)   Turbojet Sustainer - Design point altitude, Mach
        number, thrust level, and inlet temperature are input
        using Variables 9 through 12. Variables 13 through
        16 are input with dummy values.

Those propulsion design parameters are defined in Figure III-4. The con-
trol option ITHR is prestored as zero, but may be changed through input
of a SUPER list.

Basic variable number 17 is assumed to be missile total weight if
INWØRL=0, and to be missile total length if INWØRL=1. The control
parameter, INWØRL, is prestored as zero but may be changed through
the SUPER NAMELIST (see Figure III-29). Limitations on the user's
choice of length or weight as variable number 17 are shown on Figure
III-3. For example, turbojet sustainers must be sized to a weight and
not to a length.

Payload compartment length (variable 4) is the total linear space required to package all "payload" components. Payload components include the warhead, guidance and control equipment, miscellaneous equipment, radar, and void spaces. Those components may be contiguous or may be distributed arbitrarily along the missile. Payload weight is compiled within the CGSM by summing the warhead weight (variable 5), the controls system weight (variable 6), the miscellaneous payload weight (see WMISC in the SUPER NAMELIST list of Figure III-29), the guidance system weight (see WTGUID in the NAMCST NAMELIST of Figure III-31), and the airframe skin weight around the payload components (computed internally based on the input nose shape and payload compartment length).

2.2 COMPATIBILITY MATRIX

Selective permutations of CGSM basic variables can be suppressed through input of an optional compatibility matrix. That matrix is loaded immediately after a ZIP card with code "ZIP 11 1", and is itself followed by a SUPER NAMELIST list.

The compatibility matrix is labeled M_{ij} and has the form:

$$M = \begin{vmatrix} e_{1,1} & e_{1,2} & \cdots & e_{1,m} \\ e_{2,1} & e_{2,2} & \cdots & e_{2,m} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ e_{n,1} & e_{n,2} & \cdots & e_{n,m} \end{vmatrix}$$

Each element of the matrix corresponds to a pair of basic variable values. If an element has a non-zero value, the basic variable values tied to that element are judged to be compatible, and the CGSM executive will attempt to synthesize a missile using them. If an element is assigned a zero value through input of a compatibility matrix, the pair of values. corresponding to that element are labeled incompatible, and synthesis of a missile is suppressed when those values would be combined. If no matrix is input, prestored values label all permutations of all basic variables as compatible.

Use and input of the compatibility matrix is illustrated through the sample matrix of Figure III-5, by reference to the sample basic variables table of Figure III-4. That sample basic variables table defines a set of potential ramjet cruise missiles. A total of nine permutations are possible within that set, since three diameters and three weights are specified. The compatibility matrix in Figure III-5 reduces that total to three, and allows the following permutations:

No.	Diameter	Weight
1	18	3500.
2	19	3750.
3	20	4000.

FIGURE III-5

CGSM INPUT - COMPATIBILITY MATRICES

```
ZIP  11  1                                          READ COMPATIBILITY MATRIX          A
TABLE NO.  2010000                                                                     B
SAMPLE MATRIX                                        NUMBER OF MATRICES =          1    C
COMPATIBILITY MATRICES KEYS ON NEXT CARD (BV 7 ≠ 17) GROUP =                      1    D
1(7,17)
COMPATIBILITY MATRIX NO.1   1  0  0     1=GROUP  3x3 MATRIX (DIAM VS. WT)     1=GROUP   E
11  12  13      1   0   0                                                              F
21  22  23      0   1   0
31  32  33      0   0   1                1=GROUP                                       G
```

Figure III-5 (Cont'd.)

VARIABLE/CARD   DEFINITION

A   ZIP code card. Format includes:

Column	Parameter
1 - 4	ZIP designator (A4)
5 - 10	ZIP number (3I2)
11 - 40	Not used (I10, 4I5)
41 - 80	Optional comment space (10A4)

B   Table identifier card. Format includes:

Column	Parameter
1 - 12	Optional comment space (12X)
14 - 20	Table No. 2010000 (I7)
21 - 30	Not used (10X)
31 - 35	Case number (user optional) (I5)
36 - 80	Not used (46X)

C   Number of compatibility arrays input (maximum of 8).

Column	Parameter
1 - 60	Comment space (15A4)
61 - 70	Number input (I10)
71 - 80	Not used (10X)

D   Concept group number.

Column	Parameter
1 - 60	Comment space
61 - 70	Group no. always set to one (I10)
71 - 80	Not used (10X)

E   Key which specifies basic variables covered by the compatibility matrix. The key used on the sample matrix specifies that a compatibility check is required between basic variables 7 and 17.

Figure III-5 (Cont'd.)

VARIABLE/CARD   DEFINITION

Column	Parameter
1 - 10	Key for matrix no. 1
1 - 3	Matrix no. (I3)
4	Comment space (1X)
5 - 6	First basic variable no. (I2)
7	Comment space (1X)
8 - 9	Second basic variable no. (I2)
10	Comment space (1X)

A separate key is required for each matrix, up to the total number input on Card C. Columns 11 through 20 are set aside for the second matrix key, 21 - 30 for the third, and so on. The ten columns allocated to each key are broken down parallel to that listed above for the first key. Variable numbers must be drawn from the list defined in Figure III-4.

F   Identifiers for each matrix.

Column	Parameter
1 - 4	The symbols "CØMP" must be punched in these first columns (A4)
5 - 25	Optional comment space (5A4, A1)
26 - 30	Matrix number (I5)
31 - 65	Optional comment space (10X, 6A4, A1)
66-70	Group number always set to one (I5)
71-80	Not used (10X)

Figure III-5 (Cont'd.)

VARIABLE/CARD   DEFINITION

G   The set of cards labeled "G" is used to input
             compatibility matrix elements. Cards G and F
             are repeated for each matrix. Each matrix is
             designated M_{ij}, and each card in "G" loads a
             matrix row. Cards are formatted as:

Column	Parameter
1 - 10	Optional comment space (10X)
11 - 80	Matrix elements for a given row (M_{ij}; i = constant; j = 1, 2, ... m; m = input) (15I5)

Two cards (identical in format) are required if
m > 15. An upper limit of 16 is imposed on m
since no more than 16 values can be input for
any of the basic variables. The limit on m is set
operationally by the Card "D" of the basic variable
set (see Figure III-4) for matrix variable no. 2.
The limit on number of rows for each matrix is
set during basic variable table input by the Card
"D" which corresponds to matrix variable no. 1.
One card is required for each row (2 if m > 15).
A zero value in any field stores a zero for the
element, e_{ij}, corresponding to that field, and labels
incompatible the jth value of matrix variable no. 1
and ith value of matrix variable no. 2. Any non-
zero setting labels the matrix variables as com-
patible and enables missile synthesis for that
combination of variables.

Steps in assembling the matrix are as follows:

(1)   Card A is loaded as a "ZIP 11 1" to instruct the CGSM executive that a compatibility matrix will follow the ZIP card and precede the SUPER NAMELIST.

(2)   Card B is loaded with the same table number as Card B of the basic variables table (2010000 is required for the CGSM).

(3)   Card C is punched with comments and a value of one in column 70 to specify that a single matrix will follow.

(4)   Card D includes optional comment space and a group number which must be one for CGSM applications.

(5)   Card E loads a single key for the single matrix. Basic variable no. 7 (diameter) is loaded as the first matrix variable. Basic variable 17 (weight) becomes matrix variable no. 2.

(6)   Card F begins with "COMP" in columns 1 - 4. Comments shown on Figure III-5 are recommended but are not mandatory. Comments listed under "A" format are reproduced in the printout of the table but are not used otherwise. Group number and matrix number are punched on Card F as ones.

(7)   Card set G includes 3 cards with non-zero values in the fields shown on Figure III-5. Since a value of 3 was loaded on card D7 of the basic variables table, the matrix consists of three elements per row (three columns), and each card in set G contains three element values. Since three values of basic variable no. 17 (see card D17) were loaded, card set G consists of three cards. By punching in a value of zero in all except elements $e_{1,1}$, $e_{2,2}$, and $e_{3,3}$, the six unwanted combinations of weight and diameter are suppressed.

3.0   NAMELIST INPUT DESCRIPTION

A total of twenty-five specialized NAMELIST lists are used in the CGSM. Their functions are input/output control and data input. CGSM lists follow the general FORTRAN IV NAMELIST rules listed on Figure III-6. CGSM input decks can be large; however, the following steps have been taken to limit the volume of input for a given JOB:

(1)   All NAMELIST parameters have been assigned pre-stored values, and only those which need to be changed from those prestored values are required as input.

(2)   All NAMELIST values are saved within the CGSM executive logic for the duration of a JOB, and input for stacked cases need only include changes from the previous case.

(3)   Use of ZIP control cards makes the lists self-loading, so that they may be input in any order or may be omitted altogether for a given JOB.

A CGSM JOB which uses primarily prestored data may require as few as 50 cards.

Multiple lists are provided with the purpose of helping the user to sort out the many types of input data, and of making the overall input task simpler. A summary of all CGSM NAMELIST is included as Figure III-7. That summary describes the types of data which were assigned to each NAMELIST. All liquid rocket sustainer design and sizing data are assigned to the NAMLR list, for example, and the user need only be concerned with the NAMLR list if his JOB calls for a missile with a liquid rocket sustainer. In general, the user may confine his attention to those lists which are necessary for his unique JOB. The dependence of input requirements on the user's selection of synthesis options is illustrated on Figure III-8. The user can identify relevant input lists by tracing through that figure for a set of options.

FIGURE III-6

NAMELIST INPUT RULES

o   The first column on all NAMELIST cards must be blank.
    Column 2 of the first card must contain the ampersand (&)
    followed immediately by the NAMELIST name (e.g., &NAM1)
    and followed by at least one blank. The reading of NAMELIST
    input is terminated by putting ampersand end (&END) after the
    last number, or on the final card by itself.

o   Data may begin on the same card as the NAMELIST name
    (separated by at least one blank) and has the form:
    VARIABLE = number, followed by a comma. If the number
    is an integer (variables whose names begin with I, J, K,
    L, M, N) no decimal point is used. If the number is real,
    embedded decimal points must be used while trailing decimal
    points are optional. Do not leave blanks between numbers
    and their trailing commas. Do not split a variable name,
    or a number and its trailing comma, from one card to the
    next.

o   The same variable may appear more than once in the NAME-
    LIST input deck and the last value is the one used. Not all
    variables belonging to a NAMELIST need appear at input time.
    If they are not on the input card, their current value is
    unchanged in core. A variable may belong to more than one
    NAMELIST list.

o   If a variable is dimensioned, i.e., is subscripted, such as
    KBOOST (2, 2), this means there are actually four variables
    identified by the indices as KBOOST (1, 1), KBOOST (2, 1),
    KBOOST (1, 2), and KBOOST (2, 2) in this order. Note that
    the left-most index varies most rapidly. They may be read
    one at a time or all at once. For partial lists, the indices must
    be specified, e.g.

        KBOOST (1, 2) = 1,   KBOOST (2, 1) = 0
        KBOOST (1, 1) = 3,   KBOOST (2, 2) = 2, .

    If the numbers are read all at once, the indices may be
    omitted and the above is equivalent to:

        KBOOST = 3, 0, 1, 2, .

FIGURE III-7

NAMELIST DESCRIPTIONS

NAMELIST NAME	INPUT DATA DESCRIPTION	SEE SECTION NO.	FIGURE NO.
NAM1	Output Control Options	3.1	III-12
NAMCNF	Configuration Data	3.2	III-13
NAMPAK	Packaging Data	3.3	III-14
NAMBOO	General Booster Data	3.4	III-15
NAMEXB	External Booster Data	3.5	III-16
NAMSR	Solid Rocket Sustainer Data	3.6	III-17
NAMLR	Liquid Rocket Sustainer Data	3.7	III-18
NAMRJS	Ramjet Sustainer Design Data	3.8	III-19
NAMFLR	Turbojet Sustainer Design Data	3.9	III-20
NAMTRS	Ramjet Fuel Temperature Rise Tables	3.10	III-21
NAMSPH	Ramjet Fuel Specific Heat Ratio Tables	3.10	III-22
NAMGSC	Ramjet Fuel Gas Constant Tables	3.10	III-23
NAMBSP	Ramjet Fuel Burner Severity Tables	3.10	III-24
NAMINM	Air Inlet Performance Map	3.11	III-25
NAM3	Worth Data	3.12	III-26
NAMVPM	Trajectory Control Terms	3.13	III-27
NAMBYP	Options for Bypass of Computational Steps	3.14	III-28
SUPER	Supervisory List	3.15	III-29
NAMSCR	Screening Control Data	3.16	III-30
NAMCST	Cost Data	4.1	III-31
NAMCBY	Cost Data for Bypass	4.2	III-32
NAMCNP	RCM CER Data	4.3	III-34
NAMCCN	RCM CER Data	4.3	III-35
NAMCPS	RCM CER Data	4.3	III-36
NAMCCP	RCM CER Data	4.3	III-37

Figure III-8

INPUT REQUIRED FOR SYNTHESIS OPTIONS

III-27
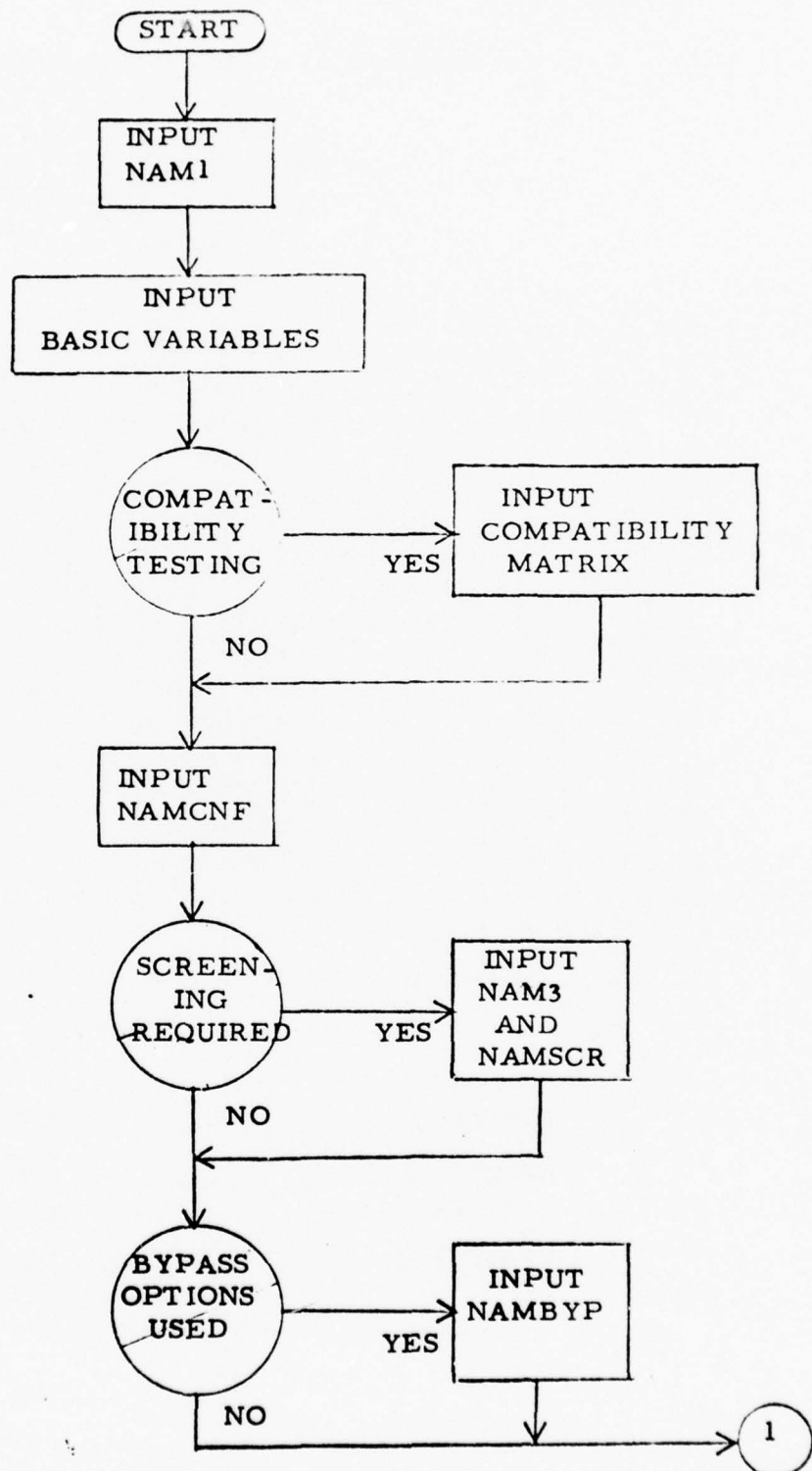
Figure III-8 (Cont'd.)
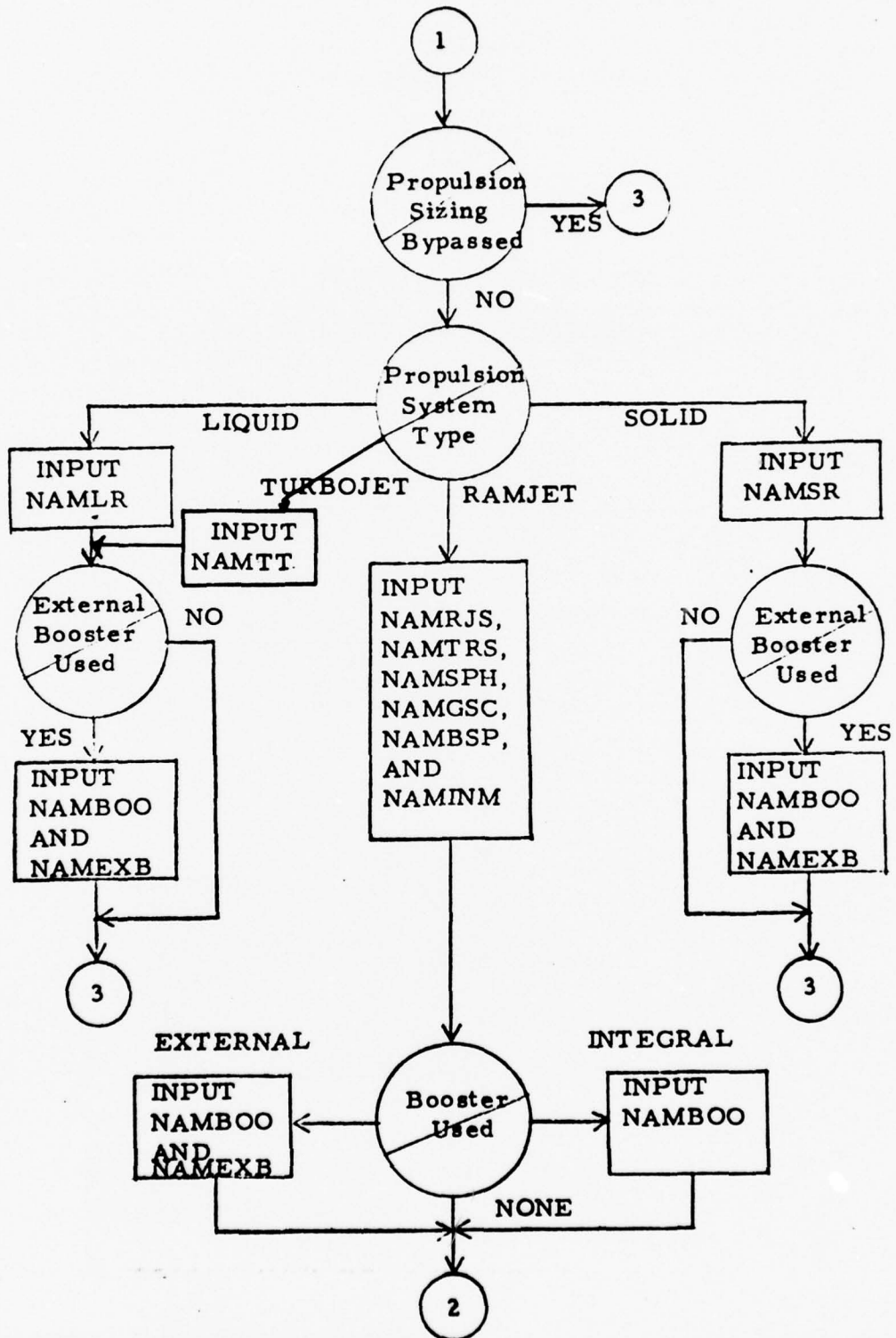
Figure III-8 (Cont'd.)

Figure III-8 (Cont'd.)
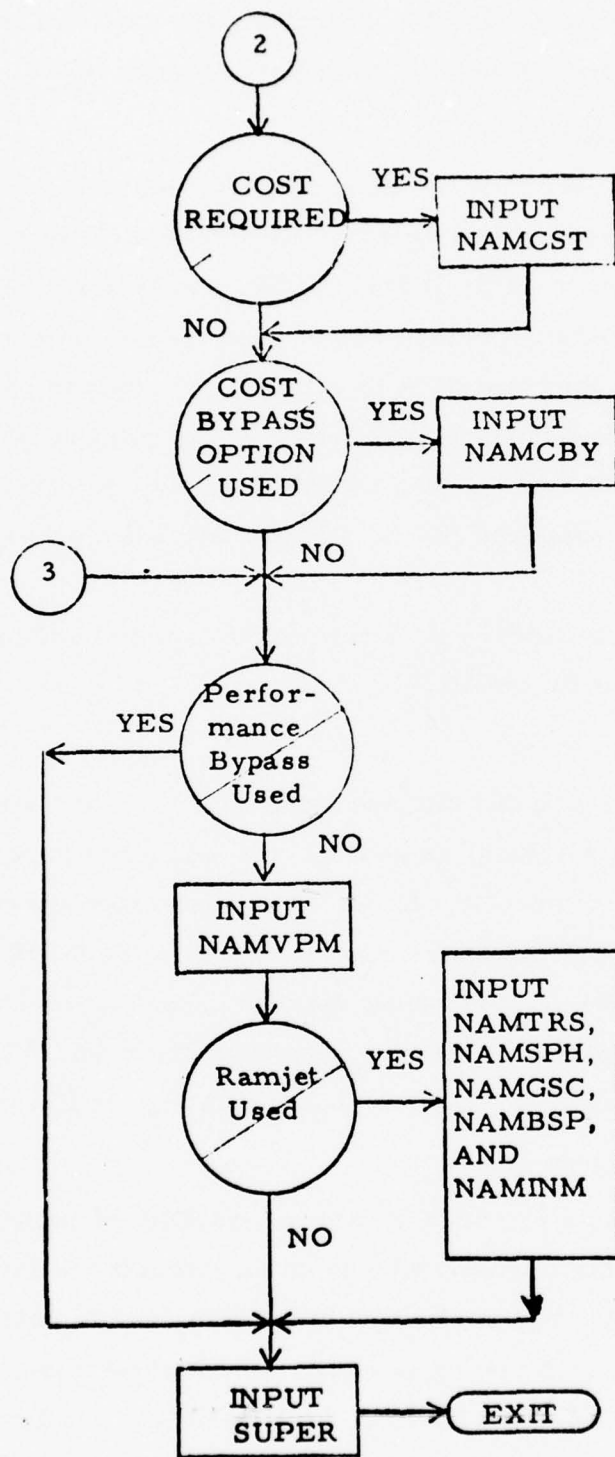
Each NAMELIST list is discussed separately in the following sections. A complete list of parameter definitions for each list is included at the end of this section (see Figure III-11 through III-29).

3.1 NAM1 LIST DESCRIPTION

The NAM1 list is used to input those control flags governing CGSM printed output. The list parameters, INPRIN and IPRP, control print during the input steps. IAIR, IPSM, ICOST, and IVP control output during missile synthesis and trajectory steps. The NAM1 list may appear at more than one point in the input deck to selectively suppress print during input; however, the NAM1 values current at the point of reading the SUPER NAMELIST are used to control synthesis output. The parameter KFIL12 is used to suppress file 12 data storage when screening is not required.

Prestored values in NAM1 call for minimum printed output. List parameters are defined in Figure III-12.

3.2 NAMCNF DESCRIPTION

The NAMCNF list includes the payload, wing, tail, and airframe design and sizing options and data, as well as miscellaneous parameters used in aerodynamics computations. Several parameters which would logically be assigned to NAMCNF have been deferred to the SUPER NAMELIST for convenience in assembling stacked cases, however. All list parameters have prestored values. A complete definition of list parameters and their prestored values is included in Figure III-13.

3.3 NAMPAK DESCRIPTION

All input parameters required to test the viability of packaging each generated concept into a launch tube or on an aircraft are input through the NAMPAK list. The parameter KLNCH is used to designate whether surface or air launch testing is required. Testing is bypassed if KBYPAK=1 in SUPER (see Figure III-29). List items and prestored values are presented on Figure III-14.

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3.4 NAMBOO DESCRIPTION

Data input through the NAMBOO list apply to the design and sizing of integral and external boosters. Principal parameters include characteristic exhaust velocity (CSTAR), thrust coefficient (FJ), ambient pressure (PA), and chamber pressure (PC). These NAMBOO list items are combined with an input delivered thrust-to-weight ratio (basic variable no. 8), and with an ideal velocity and payload weight determined internally, to size the booster. A design point is implicit in the selection of inputs (see PA, CSTAR, T/W, etc.) but is not input otherwise.

External booster sizing requires input of both NAMBOO and NAMEXB. All other boost stages require only NAMBOO. Some booster control options are deferred to the SUPER NAMELIST (Figure III-29).

List parameter definitions and their prestored values are included as Figure III-15.

3.5 NAMEXB DESCRIPTION

Boost stage design and sizing parameters which apply only to external boosters are input through NAMEXB. Those parameters are combined with the NAMBOO list items. External booster control options are deferred to the SUPER NAMELIST. NAMEXB list items are defined in Figure III-16.

3.6 NAMSR DESCRIPTION

Solid rocket sustainer design and sizing data are listed in NAMSR. Those list parameters are combined with the solid rocket design point input through the basic variables table. Figure III-17 presents a complete listing of NAMSR parameter definitions.

3.7 NAMLR DESCRIPTION

Liquid rocket sustainer design and sizing data are input through NAMLR. Those list parameters are combined with the liquid rocket design point input through the basic variables table. NAMLR list items are defined in Figure III-18.

3.8 NAMRJS DESCRIPTION

Ramjet Sustainer design and sizing data are input through the NAMRJS list. Those data are combined with the ramjet design point data input through the basic variables table. NAMRJS applies to all ramjet sustainer options, whether integral, unboosted, or externally boosted.

Several ramjet fuel data items are included in NAMRJS. The parameters IFTYPE, PT41, PT42, and PT43 control input and interpolation in the fuel performance maps.

All NAMRJS list parameters are defined, and their prestored values are listed, in Figure III-19.

3.9 NAMTJ DESCRIPTION

Turbojet sustainer design and sizing data are input through NAMTJ. Those list parameters are combined with the turbojet design point input through the basic variables table. NAMTJ list items are defined in Figure III-20.

3.10 RAMJET FUEL MAP INPUT

Ramjet fuel characteristics must be defined throughout the ramjet operating regime in terms of temperature, pressure, and fuel/air ratio. Four maps must be input for a given fuel type. The first three maps are three-dimensional tables defining temperature rise, specific heat, and gas constant variations. The fourth map defines the linear variation of combustion efficiency and lean blow out ratio with burner severity parameter.

Fuel maps may be input through NAMELIST lists or through optional formatted data decks with proper settings of ZIP control cards. For either input method, the following data are required:

(1) Map 1 - Fuel temperature rise versus free stream total temperature (TT2), fuel-to-air ratio (F/A), and combustion pressure (P).

(2)   Map 2 - Specific heat versus combustion temperature (TT4), F/A and P.

(3)   Map 3 - Gas constant versus TT4, F/A and P.

(4)   Map 4 - Combustion efficiency and lean blow out ratio versus burner severity parameter.

Three pressure levels are required for temperature rise data tables; however, specific heat and gas constant data tables may be assembled with one or three pressures depending on the setting of IFTYPE in the NAMRJS list.

The option of NAMELIST input for the fuel data is useful since it allows maps to be prestored. A complete set of JP5 fuel data is stored in the CGSM through BLOCK DATA and is available to the user. Input of blank NAMELIST lists is recommended when JP5 fuel is to be used , since that causes the tables to be printed during the input step.

3.10.1 NAMTRS, NAMSPH, NAMGSC and NAMBSP Descriptions

Ramjet fuel performance characteristics may be input through the following lists:

(1)   NAMTRS - Temperature rise (Map 1)

(2)   NAMSPH - Specific heat (Map 2)

(3)   NAMGSC - Gas constant (Map 3)

(4)   NAMBSP - Burner severity (Map 4)

Standard NAMELIST rules and conventions apply to these lists and their data.

The procedure for assembling the data tables of Maps 1, 2, and 3 for NAMELIST input is explained through the following example. The procedure is identical for each of the three maps, but gas constant (Map 3) is singled out for illustration. Gas constant data should be arranged as in Figure III-9 as a preparatory step. Data arrays are grouped into "subtables", where each such subtable corresponds to a specified ramjet combustion temperature (TT4B), and where each

Figure III-9

RAMJET FUEL MAP LAYOUT - GAS CONSTANT

SUBTABLE			COLUMN					
NO.	TT4B	VARIABLE	1	2	3	4	5	6
1	400	FAR2	0.	.06				
		GASLØ	53.35	53.35				
2	3200	FAR2	0.	.10				
		GASLØ	53.35	53.35				
3	3600	FAR2	0.	.07	.08	.09	.10	
		GASLØ	53.35	53.40	55.10	56.58	58.05	
4	4000	FAR2	0.	.07	.08	.09	.10	
		GASLØ	53.40	53.62	55.10	56.60	58.05	
5	4400	FAR2	0.	.06	.07	.08	.09	.10
		GASLØ	53.45	53.53	53.87	55.15	56.63	58.08
6	4800	FAR2	0.	.05	.06	.07	.08	.10
		GASLØ	53.55	53.72	53.87	54.25	55.35	58.20

includes the dependence of gas constant (GASLØ) on fuel-to-air ratio (FAR2). A "column" designation is assigned to each set of GASLØ/FAR2 data points. All subtables and columns are independent in length and value, as shown on Figure III-9. In assembling the sample tabular data for NAMGSC input (see also Figure III-23), the following steps are required:

(1)   The number of subtables (6) is input through the parameter K4.

(2)   The number of columns in each sequential subtable (2, 2, 5, 5, 6, 6) is input through the array KN(I).

(3)   The temperature values corresponding to each sequential subtable (400, 3200, 3600, 4000, 4400, 4800 deg R) are input through the array TT4B(I).

(4)   Fuel-to-air ratio values are input through the two-dimensional array FAR2 (I, J), where I corresponds to subtable number and J corresponds to column number. Under that format, the following values may be observed:

   FAR2(1, 1) = 0.0
   FAR2(1, 2) = .06
   FAR2(6, 6) = 0.10

(5)   Gas constant values are loaded through the two-dimensional array GASLØ (I, J) using the same format as FAR2 (I, J).

Data shown in Figure III-9 are drawn from the prestored JP5 fuel type. That fuel type requires only one pressure level for gas constant data. If three pressure levels are required for an alternate fuel type, GASMED and GASHI (see Figure III-23) are loaded in the same manner as GASLO in step 5. As many as 15 subtables and 15 columns may be used for a given map.

Map 4 consists of an array of up to 15 values of burner severity parameter (BSP) plus corresponding arrays of (dependent) combustion efficiency and lean blow out ratio values. Those data are input through the NAMBSP list as simple arrays with BSP points arranged in increasing order. Map 4 can only be input through NAMBSP.

A complete fuel map is prestored in the CGSM using the JP5 fuel type. Definitions of list parameters and listings of prestored values are included as Figure III-21 (for NAMTRS), Figure III-22 (for NAMSPH), Figure III-23 (for NAMGSC), and as Figure III-24 (for NAMBSP).

3.10.2 Formatted Fuel Deck Input

Maps 1, 2, and 3 (see above) may be input through formatted decks if desired (see Section 1.0 for ZIP codes). Format of those decks is illustrated in Figure III-10 for a generalized map. CGSM executive logic expects the first card on Figure III-10 to be loaded immediately after the fuel map ZIP card. Actual reading of the deck is controlled by the executive based on the set of dimensioning parameters read on cards 1 and 3. The first card sets the number of subtables (as many as 15), and card 3 sets the number of data points per subtable for each variable (as many as 15). A separate control parameter is input on card 1 as either 1 or 3 in column 8. That control parameter is punched as 1 if a single pressure is to be considered, and is punched as 3 if multiple pressures are used. The setting of 1 requires that IFTYPE be set to zero in the NAMRJS list, while a setting of 3 requires that IFTYPE=1. Data cards are read under the format "10 X 6F10.0" so that multiple cards are required when NELEM > 6 for a given subtable. In that case, all of the cards for VAR2 are read before the first card of VAR3 is read, and so on through the deck.

The generalized variables of Figure III-10 are correlated to specific fuel map parameters in Figure III-11. Thus, where the generalized variable VAR1 is seen, the user substitutes TT2 (Map 1), TT4A

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FIGURE III-10

OPTIONAL FORMATTED INPUT OF RAMJET MAPS

READ SUBTABLE #NSUB

READ SUBTABLE #2

READ "VAR5(I), I=1, NELEM(1)"	(SUBTABLE #1)
READ "VAR4(I), I=1, NELEM(1)"	(SUBTABLE #1)
READ "VAR3(I), I=1, NELEM(1)"	(SUBTABLE #1)

FORMAT (10X, 6F10

READ ARRAY "VAR2(I), I=1, NELEM(I)"
FOR SUBTABLE #1

READ ARRAY "NELEM(I), I=1, NSUB"
USE FORMAT (15I2)

READ ARRAY "VAR1(I), I=1, NSUB"
USE FORMAT (10X, 6F10.0)

(OPTIONAL LABELING)

OPTIONAL LABELING

*SET TO 1 OR 3

SET TO NO. OF SUBTABLES

*Set to 3 if VAR3, VAR4, and
VAR5 are all input. Set to
1 if VAR3 and VAR4 are omitted.

2   6   8   10

Figure III-11

MAP VARIABLE NAME CORRELATION MATRIX

VARIABLE MAP	NSUB	NELEM	VAR1	VAR2	VAR3	VAR4	VAR5
FUEL TEMP RISE	K2	KK	TT2	FAR1	TRLØ	TRMED	TRHI
FUEL SPECIFIC HEAT	K3	KL	TT4A	FAR2	GAMLØ	GAMMED	GAMHI
FUEL GAS CONST	K4	KN	TT4B	FAR3	GASLØ	GASMED	GASHI
INLET PERF. (CRITICAL)	K8	KPTC	ALPHV	AAMACH	PT3PTØ	AØACC	ADDD

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(Map 2), or TT4B (Map 3) from Figure III-11. Definitions of the variable names shown on that figure are found in Figures III-21 through III-23.

3.11 RAMJET INLET DATA (NAMINM) DESCRIPTION

Two-dimensional inlet sizing and performance data are input through NAMINM. Inlet performance data include maps of inlet additive drag, mass flow ratio, and pressure ratio versus both Mach number and pitch angle. Input of the inlet maps is completely parallel to input of the ramjet fuel maps. Either NAMELIST or formatted deck input is permitted, and the steps in assembling inlet data are identical to the steps described in Section 3.10 for the fuel maps, where variable names can be correlated through Figure III-11.

The following ZIP codes direct the CGSM executive modules to read inlet data (see Section 1.0 for ZIP code formats):

ZIP CODE		INPUT OPTION
6 661	0	Read sizing list and critical map using NAMINM
6 662	0	Read sizing with NAMINM then read critical map deck

NAMELIST input cards follow the ZIP card, while deck cards follow the NAMELIST.

Two-dimensional inlet sizing and map formatting is discussed further in Vol. IIID, Appendix E. A complete definition of NAMINM list parameters is included as Figure III-25.

3.12 NAMBYP DESCRIPTION

Optional bypass input data are loaded through NAMBYP. Certain computational steps can be bypassed in favor of user input of key parameters without otherwise interrupting the computation flow. Individual steps which may be bypassed are discussed here. Bypassing of multiple steps then can be constructed as combinations of single bypass steps.

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The trajectory simulation step can be bypassed with an input of KBYVP=1. This option is useful during the initial steps of an analysis, when the propulsion system design may be loosely defined. No NAMBYP input is required to bypass the trajectory other than KBYVP=1.

Computation of aerodynamics coefficients tables can be bypassed by input of KBYDRG > 0 in NAMBYP. No further input is required if KBYVP=1 also; however, if the trajectory step is to be executed, the NAMBYP input must also include the SMACH1, SMACH2, SMACH3, SMACH4, SMACH5, CLALF1, CLALF2, CLALF3, CLALF4, CLALF5, DMACH1, DMACH2, DMACH3, DMACH4, DMACH5, CDØ1, CDØ2, CDØ3, CDØ4, and CDØ5 arrays. Ramjet sizing requires computation, or input, of design point lift and drag coefficients. Those coefficients are computed in the CGSM when KBYDRG is zero or one; however, KBYDRG=2 causes all ramjet aerodynamics steps to be bypassed. If KBYDRG is input as two, the coefficients CDØDES and CLADES must also be input.

Propulsion sizing can be bypassed by input of KBYPSM=1 through NAMBYP, along with a set of propulsion sizing and performance terms. Parameters included in that data set are dependent on propulsion system type and the choice of other bypass options. If aerodynamics tables are computed, input must include BEXIT, SEXIT, XCGD1, XLBDY, and XNOZ. If a trajectory is to be integrated and a turbojet or liquid or solid rocket is specified, input includes DRØPST, SEXIT, SUSWP, TVACMN, TVACMX, XTHRTL, and YISP. If a trajectory is to be flown and a ramjet is specified, input includes DRØPST, ACA3, A5A3, A6A3, SEXIT, and SUSWP. If a trajectory is to be flown and the missile includes a boost stage, input includes BEXIT, BISPV, BØØWP, BTHVAC, and DRØPEB. The complete input list for a propulsion bypass must be selected from the parameters named above for each JOB.

Bypass options are useful for conserving computer time and for "extending" CGSM methodology to include options, systems,

subsystems, or data which are not currently programmed. A detailed definition of NAMBYP list items is included as Figure III-27. Pre-stored values are primarily zeros. If the NAMBYP list is not loaded at all, prestored data instruct the CGSM to execute all steps with no by-passing. Independent variables for the NAMBYP data tables should be monotonically increasing.

3.13   NAMVPM DESCRIPTION

Input to the vehicle performance, or trajectory, computation steps of the CGSM is through NAMVPM. That input can be grouped into single valued parameters which control the trajectory integration, single valued parameters which define initial conditions and flight constraints, and arrays which define phase controls. Initial conditions and flight constraints appear in NAMVPM and also in the SUPER NAME-LIST. Parameters in that dual input set are ALTI, FARMAX, GAMMAI, MØPT, NCPHAZ, NDPHAZ, NLPHAZ, TPCMGN, TT4MAX, VELI, and XMACHI. Those parameters are listed under SUPER for convenience in stacking cases; however, all should be input under NAMVPM initially.

The user may specify that one, or as many as five, trajectories be flown for each synthesized missile. The procedure for requesting multiples includes the following steps.

(1)   Assemble the CGSM data deck with a NAMVPM list containing all list items for trajectory number one. Use the ZIP code "ZIP 615 1" (see Section 1.0 for formats).

(2)   Place an additional NAMVPM list after the list described in step (1) but before the SUPER list. Use the ZIP code "ZIP 615 2".

(3)   Place additional NAMVPM lists in the deck (up to a total of five trajectories) after the first trajectory list but before SUPER. In each case use "ZIP 615 n", where n is the trajectory number.

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The order in which trajectories 2 through n are loaded is not constrained since the trajectory number (which is used to store and retrieve list items) is loaded on the ZIP card. A comprehensive set of data is stored for each trajectory, including VELI, XMACHI, GAMMAI, ALTI, MØPT, NLPHAZ, NCPHAZ, and NDPHAZ, as well as all of the phase data arrays. All of those parameters must be set for the first trajectory (prestored values may be used if desired). Parameters input for trajectory no. 1 then carry over to the next NAMVPM list, so that input for trajectory no. 2 may be limited to changes desired from no. 1 to no. 2. In like manner, input loaded for trajectory n is available for trajectory n+1. The complete set of trajectories carries over when cases are stacked. When multiple trajectories are input, the CGSM assigns each trajectory/design combination as a separate, screenable concept.

The user may specify as many as 20 trajectory phases to be flown, and may define path controls and termination constraints for each phase. A phase, in the CGSM terminology, is an interval of flight during which path controls and termination controls are fixed. Termination controls may be independent of path controls, as in the case of any phase where termination is at fuel depletion, or those controls may be coupled. An example of the latter case is when the missile is directed to fly an altitude profile and terminate at an altitude within the profile. Termination control parameters include the phase arrays ITERM, FVALUE, TPHASE, TTØTAL, and SLØPE. Remaining phase parameters are used for path control.

Input to the CGSM vehicle performance model is broken into phases to reduce input complexity and increase the visibility of the resulting trajectory. The actual numerical integration is conducted step-by-step using "current" path and termination controls and a "current" state vector, however, and this integration must cross from phase to phase until the complete trajectory is flown. Conflicting requirements between two consecutive phases may result in a transition period in which excessive demands are placed on the missile, or

on the control logic, and may result in termination of the integration at that point. The performance model has the capability to recover from many such situations (for example, the missile may be pitched down in an attempt to pick up speed if CGSM logic detects that current velocity is inadequate for the current path control option). The CGSM will not change phases when recovery is attempted since its objective is to search for and enforce conditions which meet the "current" control options. The user should construct phase controls to allow a reasonable transition period between phases. Recovery attempts can be recognized in the detailed trajectory output.

The user may inadvertently request a set of trajectory phases which the synthesized missile is incapable of flying. In that event CGSM-recovery logic will take over and attempt to salvage the phase. If phase termination conditions are met during the recovery attempt, the phase is terminated and the CGSM exits from the recovery mode and proceeds to integrate the next phase. Following this chain of events, if the integration logic can then readily meet "current" path controls, the entire trajectory may be flown and registered as a success. If the missile never completely recovered from its control problems in that early phase, the resultant trajectory may have been degraded, and may be unacceptable to the user (subject to a value judgement). The degradation may take the form of a cruise phase which is flown at an altitude or velocity which is slightly under requirements. If such conditions arise, the user may modify the missile design through the design point parameters in NAMBOO, NAMEXB, NAMSR, NAMLR, NAMTJ, NAMRJS, SUPER, etc., or may modify trajectory requirements.

Most of the CGSM path control options require the user to input tabular data through $CONI_i$ and $COND_i$. Those tabular data completely define the flight path for the phase. This is true of path options accessed by ICONT=1, 2, 3, ..., 11, and is true for ICONT=12 if MHGEN=0 for a given phase. Three path control options, however,

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offer internally computed path control. A constant altitude cruise phase can be accessed by setting ICONT = 13 for the phase of interest. In the integration of cruise phases, the CGSM controls sustainer thrust so that it matches the thrust required to fly the missile at the desired altitude. Setting ICONT = 12 and MHGEN = 1 during a phase causes the CGSM to generate, and fly, an altitude versus Mach number schedule. A climb is normally transitioned into a level-off phase by terminating the climb phase with an ITERM value of 7. The level-off phase (specified by ICONT = 14) regulates vehicle load factor and sustainer thrust to maintain a desired Mach number while causing the flight path angle to become zero at the same time that the required cruise altitude is reached.

Success of the climb and level-off phases depends on the user's selection of a level-off load factor with which to terminate the climb under the ITERM = 7 option. At each integration step during the climb phase, the load factor required to level off is computed based on the "current" state vector. The climb phase is terminated when that required load factor equals the input final value (FVALUE), and the CGSM immediately transitions into the level-off. Acceleration normal to the missile path, a_N, is computed at each step as:

$$a_N = \frac{-\dot{h}}{2 g_o} \left| \frac{\dot{h}}{\Delta h} \right| ,$$

where:

$\dot{h}$ is altitude rate,

Δh is cruise minus current altitude

and g_o is the acceleration due to gravity (sea level).

The user can select a level-off load factor for input as FVALUE by reference to the following relationship:

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$$FVALUE = 1.0 + a_N,$$

or

$$FVALUE = 1.0 - \frac{V_{\sin \gamma}}{2 g_o} \left| \frac{V_{\sin \gamma}}{ALTF - h} \right|,$$

since $\dot{h} = V \sin \gamma$,

where V = reference velocity (ft/sec)

           γ = reference path angle (deg)

     $ALTF$ = cruise altitude (ft)

and h = reference altitude (ft)

This represents the load factor required to level off starting at the point
defined by V, γ , and h, and ending at an altitude defined by ALTF.
Transition from a climb to a level off is generally at negative or zero
load factors, while positive load factors must be used for transition
from a dive to a level-off.

All NAMVPM list parameters are defined in Figure III-28.
Prestored values are designated on that figure. All except integration
control variables are prestored as zero.

3.14   SUPER DESCRIPTION

A supervisory NAMELIST has been included and labeled SUPER.
That list includes a collection of the most often varied inputs to the pay-
load, wing, tail, airframe, propulsion system, and inlet sizing modules
and to the trajectory and aerodynamics computation modules. The
SUPER list is intended to facilitate the stacking of cases by reducing
the number of lists which must be loaded for the second and subsequent
cases. NAMELIST SUPER is loaded with a ZIP code of "ZIP 11 1 1" or
"ZIP 11 1" (see Section 1.0 for formats). Loading of that ZIP card and its
SUPER list automatically starts the missile synthesis. SUPER list items
are defined in Figure III-29. Prestored values are included on that figure.

3.15   NAMSCR DESCRIPTION

Screening control data are input through NAMSCR. A definition
of list items is included as Figure III-30.

FIGURE III-12

CGSM INPUT - I/O CONTROL OPTIONS
(NAM1 NAMELIST)

VARIABLE	DEFINITION
LAIR	Aerodynamic output control option -1 = 0 No output = -1 Detailed output for each concept
ICOST	Relative cost output control option -1 = 0 No output = -1 Summary output for each concept = 1 Detailed output for each CER for each concept
INPRIN	NAMELIST output control option [1] = 0 Do not print NAMELIST lists = 1 Print each list as it is input
IPRP(1)	ZIP output control [1] = 0 Do not output ZIP cards = 1 Print ZIP cards as input
IPRP(2)	Basic Table output control [1] = 0 Do not output Basic Tables = 1 Print tables as input
IPRP(3)	Column heading output control [1] = 0 Do not print column headings = 1 Print headings of Basic Tables as they are input
IPSM	Propulsion sizing output option [-1] =0 No output = -1 Output detailed data during sizing for each concept = -2 Summary output during sizing plus off design table
IVP	Trajectory output control option [-1] = 0 No output = -1 Output detailed data on missile trajectory during vehicle performance computation = -2 Same as -1 option plus output of climb schedule

FIGURE III-12 (Cont'd.)

VARIABLE	DEFINITION
KFIL12*	Suppression flag for File 12 data storage 0
	= 0 Store data on File 12 for screening
	= 1 Suppress File 12
NPAGE	Initial page number for labeling output 3

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* KFIL12 may be set to 1 when screening is not required, and the run time for that JOB will be reduced substantially.

FIGURE III-13

CGSM INPUT - CONFIGURATION TERMS
(NAMCNF NAMELIST)

VARIABLE	DEFINITION
ALTV(I), I=1, 10	Altitude values to be used in generating the lift/drag coefficient tables [0, 40000, 100000, 7*0 ft.]
ARVT	Aspect ratio of the vertical tail panel [.99]
**FACTØR	Base annulus sizing parameter [0.5]
FSØVCT	Ratio of flat section length over tail chord [0.]
FSØVCW	Ratio of flat section length over wing chord [0.]
FSØVVT	Ratio of flat section length over vertical tail chord [0.]
GULT	Maximum normal load factor for wing/tail weight computations [10.]
ILUG	Launch lug code [0] = 0 No lugs = 1 Launch lugs used
*IPLANT	Tail planform input options [1] = 1 Input aspect ratio (ART, ARVT) and taper ratio (TRT, TRVT) = 2 Input aspect ratio and leading edge sweep (SLET, SLEVT) = 3 Input aspect ratio and design Mach number (RMDES) = 4 Input aspect ratio, taper ratio and non-zero trailing edge sweep (STET, STEVT)
*IPLANW	Wing planform input options [1] = 1 Input taper ratio (TRW) = 2 Input leading edge sweep (SLEW) = 3 Input design Mach number (RMDES) = 4 Input taper ratio and non-zero trailing edge sweep (STEW)
IWTS	Wing and tail weight computation options [3] = 1 Use input wing weight (WWINGI) and tail weight (WTI) = 2 Computes weights using area times density (WOVAT, WOVAHT, WOVAVT, and WOVAW) = 3 Compute weights using empirical formulae

FIGURE III-13 (Cont'd.)

VARIABLE	DEFINITION
NALT	Number of altitudes to be used in generating the lift/drag coefficient tables [3]
NRM	Number of Mach numbers to be used in generating the lift/drag coefficient tables [6]
PANWHT	Horizontal tail panel weight - lb. [25]
PANWT	Cruciform (or triform) tail panel weight - lb. [20]
PANWVT	Vertical tail panel weight - lb. [25]
RL5	Location of intersection of wing leading edge and body in percent of total missile length 50. in
RMDES	Wing design Mach number 2.0
RMV(I) I=1, 20	Mach numbers to be used in generating the lift/drag coefficient tables [.4, .9, 1, 1.5, 2, 4, 14*0]
RXINT	Location of maximum thickness of tail chord relative to tail leading edge (L.E.) in fraction of tail chord [0.5]
RXINVT	Location of maximum thickness of vertical tail chord [0.5)
RXINW	Location of maximum thickness of wing chord [0.5]
SLET	Tail leading edge sweep angle [38 deg.]
SLEVT	Vertical tail leading edge sweep angle [45 deg.]
SLEW	Wing leading edge sweep angle [50 deg.]
*STET	Tail trailing edge sweep angle [0 deg.]
*STEVT	Vertical tail trailing edge sweep angle [0. deg.]
*STEW	Wing trailing edge sweep angle [0. deg.]
THETAC	Nose cone half angle - rad. [.165]
TRAT	Tail thickness ratio (thickness/chord) [.04]
TRAVT	Vertical tail thickness ratio [.05]
TRAW	Wing thickness ratio [.05]
TRT	Tail taper ratio (tip chord/root chord) [0.32]

FIGURE III-13 (Cont'd.)

VARIABLE	DEFINITION
TRVT	Vertical tail taper ratio [0.4]
TRW	Wing taper ratio [0.3]
VTALOC	Fraction of input tail area to be allocated to the vertical tail [.5]
WOVAHT	Weight of horizontal tail/tail area [6 psf]
WOVAST	Unit weight of skin enclosing payload and propulsion sections [5. lb/sq. ft. area]
WOVAT	Weight of tail/tail area [6 psf]
WOVAVT	Weight of vertical tail/vertical tail area [6 psf]
WOVAW	Wing weight/wing area [6 psf]
WTI	Tail weight used if IWTS =1 [25 lb.]
WWINGI	Wing weight used if IWTS = 1 [50 lb.]
ZPØPT	Payload compartment skin weight control option [0] = 1 when skin weight is computed using WOVAST = 0 when skin weight is computed using ZSKINI =-1 when skin weight is input as ZWSKIN
ZSKINI	Skin thickness used in computing payload and propulsion section skin weights [0.4 in.]
ZWSKIN	Payload skin weight [1 lb.]

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* Trailing edge sweep angle must be zero unless IPLANT = 4 (for tails) or IPLANW = 4 (for wings). IPLANT controls both horizontal and vertical tail panels.

** FACTOR is used to compute the boattailed base diameter according to the equation:

$$DIAM = DEXIT + (D3 - DEXIT)*FACTØR$$

where   DEXIT = nozzle exit diameter,

and   D3   = diameter of propulsion section.

FIGURE III-14

CGSM INPUT - LAUNCHER PACKAGING TERMS
(NAMPAK NAMELIST)

VARIABLE	DEFINITION
BCLR	Clearance between booster case and missile 1.0 in.
CLRA	Aft clearance in surface launch tube 6 in.
CLRF	Forward clearance in surface launch tube 6 in.
DELVX	Upper clearance 6 in.
FCLR	Fuselage height above deck for air launch system 60 in.
GCLR	Minimum ground clearance for air launch system 12 in.
KLNCH	Launch platform option = 0 For surface (tube) launch = 1 For air launch
KMAIR	Air-launched mounting option 2 = 1 Mount in fuselage = 2 Mount on wings
PAKSUB	Fraction of missile submerged in the launcher fuselage (used when KMAIR=1) relative to the missile radius 0
RATCLR	Rattle space clearance 2 in.
REHTUB	Ellipse ratio of tube heads 2
THEAD	Tube head thickness
THEBST	Booster attachment angle relative to vertical plane 40 deg.
TUBTHK	Tube thickness 4 in.
KMTAIL	Air launch orientation option 2 = 1 Mount with vertical tail up = 2 Mount with vertical tail down
WINGCL	Wing clearance above deck for air launch systems 90 in.
WTMAX	Maximum missile weight 20,000 lbs.
XLTMAX	Maximum launched missile length 500 in.

FIGURE III-14 (Cont'd.)

VARIABLE	DEFINITION
DTUBMX	Maximum tube diameter 50 in.
XLTBMX	Maximum tube length 500 in.
ZPYLON	Pylon depth 18 in.

FIGURE III-15

CGSM INPUT - GENERAL BOOSTER PARAMETERS
(NAMBØØ NAMELIST)

VARIABLE	DEFINITION
ABM	Aft boss multiplier 0.
AER	Aft ellipse ratio 2.
AFAT	Port-to-throat area ratio 1. 5
AIT	Aft insulation thickness .09 in.
ASL	Aft skirt length 2. in.
ASM	Aft skirt multiplier 1.
ASWM	Aft skirt weight multiplier 0.
*CASEM	Case material code 8
CSTAR	Characteristic exhaust velocity 4779. fps
DENI	Insulation density .1615 lb/cu. in.
DLFS	Skirt extension length [0. in.]
EAR	Entrance area ratio [2.]
EPI	Nozzle expansion ratio [10]
ETAX	Volumetric loading [.9]
FBM	Forward boss multiplier [1.]
FCWM	Forward closure weight multiplier [1.]
FER	Forward ellipse ratio [2.]
FIT	Forward insulation thickness [.05 in.]
FJ	Thrust coefficient [.96]
FMPAH	Percent aft dome propellant [.5]
FSL	Forward skirt length [0.0 in.]
FSULX	Ultimate factor of safety [1.4]
FSWM	Forward skirt weight multiplier [0.]
FSYLX	Yield factor of safety [1.2]
GAM	Propellant ratio of specific heats [1.18]
GMAX	Maximum acceleration [30. g]

FIGURE III-15 (Cont'd.)

VARIABLE	DEFINITION
PA	Ambient pressure [10 psi]
PBELL	Fraction bell nozzle, adjusted where 1. = 100 percent bell [1.]
PC	Chamber pressure [1070 psi]
PCM	Maximum chamber pressure [2000 psi]
PHI	Nozzle half angle [21 deg.]
PSUB	Percent nozzle submerged [0]
RBOSS	Ratio of ignitor boss area to throat area [.5]
RHOP	Propellant density [.0628 lb/in^3]
RMASW	Miscellaneous aft skirt weight [0. lb.]
RMAW	Miscellaneous aft weight [0. lb.]
RMCW	Miscellaneous cylinder weights [0. lb.]
RMFSW	Miscellaneous forward skirt weight [16 lb.]
RMFW	Miscellaneous forward weight [0. lb.]
RMIW	Ignitor weight multiplier [.3]
RNBWM	Nozzle boss weight multiplier [2.42E-6]
RNEC	Nozzle exit cone exponent [6.8E-10]
RNECC	Nozzle exit cone multiplier [2.864E-6]
RNEC1	Nozzle exit cone weight exponent [.8]
RNEC2	Nozzle exit cone weight exponent [1.]
RNEC3	Nozzle exit cone weight exponent [1.7]
RNMW	Nozzle miscellaneous weight [5 lb.]
RNRM	Nozzle retainer multiplier [0.]
RNTM	Nozzle throat multiplier [1.216E-4]
RNTWM	Nozzle throat weight multiplier [1.834]
SAW	Safing and arming weight [0.0 lb.]
SEM	Skirt elasticity modulus [1.E7]

FIGURE III-15 (Cont'd.)

VARIABLE   DEFINITION

TCASEF   Case temperature 900°R

TL   Linear thickness   .09 in.

TMIN   Minimum case thickness   .07 in.

TR   Tandem combustor structural thickness   .05 in.

TTH   Nozzle entrance arc [45 deg.]

VRFH   Forward void area [0.]

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* Material codes include: 6 - AZ31B-0 magnesium
   1 - AISI 150 psi steel   7 - 6AL-4V titanium
   2 - AISI 200 psi steel   8 - Rene 41
   3 - 300 gr maraging steel   9 - WC129Y Columbium
   4 - 17-4Ph stainless   10 - Glass fabric epoxy laminate
   5 - 2014-T6 aluminum   11 - Filament wound glass epoxy

** These terms are required only for tandem ramjet propulsion system
    sizing.

Figure III-16

CGSM INPUT - EXTERNAL BOOSTER TERMS
(NAMEXB NAMELIST)

VARIABLE	DEFINITION
C1	Dump boss multiplier [1.1]
C2	Skirt weight multiplier [1.1]
C3	Attach ring multiplier [1.1]
C4	Miscellaneous forward weight [2 lbs.]
C5	Miscellaneous cyl. weight [2 lbs.]
C6	Miscellaneous aft weight [2 lbs.]
CLEAR	Clear area between missile and tanks [2.5 in.]
EL	Ellipse ratio [2]
*MTLRAM	Combustor material code [2]
RHOENT	Entrance density [0.04 lb/in^3]
RHOEXT	Exit cone density [0.04 lb/in^3]
RHOIN	Internal insulation density [0.065 lb/in^3]
RHOTHT	Throat density [0.05 lb/in^3]
RHOX	External insulation density [0.02 lb/in^3]
TEMPC	Case design temperature [900°R]
TENT	Entrance insulation thickness [0.2 in.]
TEXIT	Exit cone insulation thickness [0.2 in.]
TEXTER	External insulation thickness [0.0 in.]
THETA	Entrance arc [45 deg.]
TINAFT	Internal aft insulation thickness [0.25 in.]
TINS	Internal insulation thickness [0.25 in.]
TMINC	Minimum sidewall thickness [0.05 in.]

Figure III-16 (Cont'd.)

VARIABLE	DEFINITION
TMIND	Minimum dome thickness [0. 05 in.]
TTHROT	Throat insert edge thickness [0. 2 in.]
WHARNS	Weight of attach harness [0. lb.]
XSTAR	Characteristic length (L*) [60 in.]

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*   Material codes include:
    1 - AISI 150 psi steel
    2 - AISI 200 psi steel
    3 - 300 gr maraging steel
    4 - 17-4 Ph stainless
    5 - 2014-T6 aluminum
    6 - AZ31B-0 magnesium
    7 - 6AL-4V titanium
    8 - Rene 41
    9 - WC129Y Columbium
    10 - Glass fabric epoxy laminate
    11 - Filament wound glass epoxy

FIGURE III-17

CGSM INPUT - SOLID ROCKET SIZING TERMS
(NAMSR NAMELIST)

VARIABLE	DEFINITION
AIAT	Igniter to throat area ratio [0.25]
APAT	Port to throat ratio [1.5]
ETACF	Thrust coefficient efficiency [.97]
EXPBR	Burn rate exponent [.82]
PBELS	Percent bell nozzle [80]
PHINØZ	Nozzle exit cone half angle [15 deg.]
REAH	Ellipse ratio of aft head [2]
REFH	Ellipse ratio of forward head [2.]
RHØISS	Insulation density [0.036 lb/cu. in.]
RHØMTL	Structural material density [0.283 lb/cu. in.]
RHØS	Propellant density [0.062 lb/cu. in.]
SIGMTL	Material strength [260,000 lb/sq. in.]
TIC	Cylinder insulation thickness [0.1 in.]
TRATIØ	Throttle ratio (maximum thrust/minimum thrust) [10]
WMSØL	Miscellaneous weight in solid motor [0. lb.]
ETSISP	Specific impulse efficiency 0.95
CSTAR1, CSTAR2	Coefficients used in computing characteristic exhaust velocity with the following equation: CSTAR = CSTAR1*ALOG(PC) + CSTAR2 where PC is chamber pressure in psf 37., 4946.

Figure III-18

CGSM INPUT - LIQUID ROCKET SIZING TERMS
(NAMLR NAMELIST)

VARIABLE	DEFINITION
DBT	Length of space between fuel and oxidizer tanks [0 in.]
ETACL	Thrust coefficient efficiency [0.97]
ETAISP	Specific impulse efficiency [0.92]
EXS1	Nozzle expansion ratio [8.]
ITANK	Tank design option [1] = 1 for embedded tanks = 2 for separate tanks
IWTANK	Tank wall thickness computation option [0] = 1 to compute wall thickness using pressure constraints. = 0 to compute thickness using bending equations. = -1 when thickness is input as TCWI.
METAL	Structural material code [3] = 1 for aluminum = 2 for titanium = 3 for steel
P1, P2, P3, P4, P5, P6, P7, P8	Constants used to compute characteristic exhaust velocity, as follows:

$$C^* = P1(P_c)^{P2} - P3(P_c)^{P4} \left\{ \left| P5(P_c)^{P6} - M_R \right| \right\}^{(P7+P8(P_c))}$$

where P_c is chamber pressure and M_R is mixture ratio

$$[5511, .00546, 176.96, .03649, 1.7, .0378, 1.468, 6 \times 10^{-5}]$$

VARIABLE	DEFINITION
PBELLL	Percent bell nozzle [80.]
PSTAR	Thruster characteristic length (L*) [75. in.]
PT	Chamber cylinder length/diameter [1.5]
PVØX	Oxidizer vapor pressure [17.2 psi]
REH	Tank head ellipse ratio [2]
RHØF	Fuel density [49.05 lb/cu. ft.]
RHØØX	Oxidizer density [89.42 lb/cu. ft.]

FIGURE III-18 (Continued)

VARIABLE	DEFINITION

SAFAC — Factor of safety used in tank wall thickness computations [1.2] [used when IWTANK = 1]

TCWI — Tank wall thickness used if IWTANK = -1 [0.05 in.]

TFRAC — Ratio of tank diameter to missile airframe diameter [1.0]

TRATIL — Throttle ratio (maximum thrust/minimum thrust) [10]

WMISCL — Miscellaneous propulsion system weight [0.0 lb.]

WØVAC1 — Chamber cylinder weight per unit area [.0581 lb/sq. in.]

WØVAC2 — Nozzle inlet weight per unit area [.0581 lb/sq. in.]

WØVAN1 — Nozzle weight per unit area for expansion ratio less than 15 [0.02 lb/sq. in.]

WØVAN2 — Nozzle weight per unit area for expansion ratios ≥ 15 [0.006 lb/sq. in.]

XØLMIS — Length of miscellaneous equipment section (to be located between tank and turbopump). [0 in.]

FIGURE III-19

CGSM INPUT - RAMJET SUSTAINER TERMS
(NAMRJS NAMELIST)

VARIABLE	DEFINITION
A6MAX	Maximum A6/A3 (nozzle exit area/combustion chamber area) [.93]
A6MIN	Minimum A6/A3 [.93]
ACMAX	Maximum AC/A3 (capture area/combustion chamber area [1.]
AL	Bleed fraction [.03]
ANN	Nozzle efficiency [.97]
CDB	Burner drag coefficient [0.]
CLX	Clear area between fuel management bay and booster [1 in.]
CNM	Nozzle mass flow coefficient [.978]
DELT4	Combustion temperature search interval [100.]
DROF	Change in fuel density per degree change in temperature [0.0 ib/cu. in. per $^{\circ}R$]
EDR	Ellipse ratio [2.]
EEXP	Expulsion efficiency [.9]
EXIN	External insulation thickness [0.0 in.]
FSLBO	Factor of safety on lean blow out [1.5]
FTUS	Ultimate safety factor [1.25]
FTYS	Yield safety factor [1.15]
GMF	Solid gas generator mass fraction [.75]
IFTYPE	Fuel deck option [0] = 0 to read specific heat ratio in NAMSPH and gas constant NAMGSC for low pressure only = 1 to read for three combustor pressures (PT41, PT42, and PT43)
KFM	Fuel management system option [4] = 1 for N_2 stored gas = 2 for LGG (liquid gas generator) = 3 for SGG (solid gas generator) = 4 for ramair turbine

FIGURE III-19 (Cont'd.)

VARIABLE	DEFINITION
*MATPB	Pressure bottle material code [2]
*MATTK	Tank material code [4]
NB	Number of N_2 bottles used if KFM=1 [0]
PDF	Injector pressure drop fraction [.05]
PKD	Inverse of packaging efficiency [2.]
PN2	N_2 pressure [2000. psi]
PT41	Low pressure level used with fuel decks in NAMTRS, NAMSPH, and NAMGSC [1060. psf]
PT42	Medium pressure level [2116. psf]
PT43	High pressure level [42324. psf]
RGD	Fuel controller pressure drop [25.]
RHOINS	External insulation density [0.0 lb/cu.in.]
RHORJF	Fuel density [.0377 lb. per cu.in.]
ROB	Bladder density [.053 lb/cu.in.]
RU	Gas constant (N_2 or SGG or LGG) [50.]
SPPWF	Secondary power package weight fraction [0.045]
TBLAD	Bladder thickness [.03 in.]
TCASEC	Minimum case thickness [.05 in.]
TFUEL	Maximum fuel temperature [75°F]
THGG	Total temperature (SGG or LGG) [2000°R]
TMAX	Maximum case design temperature [1000°F]
TSUS	Maximum operating time [100. sec.]
ULLG	Ullage fraction [.02]
VPP	Volume per pound of secondary propulsion package [10. cu. in.]
X1	Clearance between N_2 bottle and sidewall used if KFM=1 [0.1 in.]

FIGURE III-19 (Cont'd.)

VARIABLE	DEFINITION
X2	Half the clearance between N_2 bottles used if KFM=1 [.05 in.]
XMØMR	Bleed momentum recovery [0.4]

- - - - - - - - - - - - - - - - - -

* Material codes include:
   1 - AISI 150 psi steel
   2 - AISI 200 psi steel
   3 - 300 gr maraging steel
   4 - 17-4 Ph stainless
   5 - 2014-T6 aluminum
   6 - AZ31B-0 magnesium
   7 - 6AL-4V titanium
   8 - Rene 41
   9 - WC129Y Columbium
  10 - Glass fabric epoxy laminate
  11 - Filament wound glass epoxy

FIGURE III-20

CGSM INPUT - TURBOJET SUSTAINER TERMS
(NAMTJ NAMELIST)

VARIABLE	DEFINITION
ALFTJ	Design angle of attack [0 deg.]
CNLPDS	Turbine design corrected shaft speed 2.3/°R
ETABDS	Combustor design efficiency .985
ETAFDS	Compressor efficiency .829
ETLPDS	Turbine design efficiency .903
HPEXT	Horsepower extraction 0 Hp
IDIFF	Diffuser sizing option 0 = -1 use input diffuser length (XLDIFI) 0 compute diffuser length
IMCD	Main nozzle design selector 0 = 1 use convergent-divergent nozzle design = 0 use convergent nozzle design
ISTR	Structure option 1 = 1 compute structure weight based on METTJ = 2 compute using WOVAST = 3 use input WSTRI
KENG	Engine design option 1 = 1 for in-line engines = 2 for semi-submerged
SKSTR	Structure weight multiplier 1
KTANK	Fuel tank option 1 = 1 for saddle tank design = 2 for cylindrical tank only
METTJ	Structure material option 1 = 1 for aluminum = 2 for titanium = 3 for steel
TJMMAX	Maximum Mach number 2.5
OPR	Overall pressure ratio 8
PCNFDS	Design percent shaft speed 100

FIGURE III-20 (Cont'd.)

VARIABLE	DEFINITION
PRFDS	Compressor design pressure ratio
REHTJ	Fuel tank head ellipse ratio 2
RHOTJ	Fuel density 50 lb/ft^3
TFLPDS	Turbine design flow function 130 $\dfrac{lb/sec}{°R/psi}$
TJLMIS	Miscellaneous equipment section length 0 in.
WMISTJ	Miscellaneous equipment weight 0 lb.
WOVATJ	Structure weight in lb. per square foot of surface area 6 lb/sq. ft.
WSTRI	Structure weight used when ISTR=3 200 lb.
XLDIFI	Diffuser length used when IDIFF= -1 0 in.
YEAR	Year of IOC 1975

Figure III-21

CGSM INPUT - RAMJET FUEL TEMPERATURE RISE TABLES
(NAMTRS NAMELIST)

VARIABLE	DEFINITION
K2	Number of subtables input
KK(I), I=1, 15	Number of entries per subtable
TT2(I), I=1, 15	Total temperature of station 2 (one value for each table from 1 to K2)
FAR1(I,J), I=1, 15, J=1, 15	Fuel to air ratio for subtables I and columns J
*TRLØ(I,J), I=1, 15, J=1, 15	Temperature rise at low combustor pressure (for subtables I and columns J)
*TRMED(I,J), I=1, 15, J=1, 15	Temperature rise at medium combustor pressure (for subtables I and columns J)
*TRHI (I,J), I=1, 15, J=1, 15	Temperature rise at high combustor pressure (for subtables I and columns J)

- - - - - - - - - - - - - -

* Low, medium and high pressures are set by PT41, PT42, and PT43 in NAMELIST NAMRJS.

NOTE: Prestored values are listed on facing pages. Table values not shown are zeros.

FIGURE III-21 (Continued)

FIGURE III-21 (Continued)

FIGURE III-21 (Continued)

TRMED= 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0

TRHI= 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0

FIGURE III-21 (Continued)

TRMED= 0.0

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
744.50000	707.50000	667.50000	632.00000	601.89990	572.19995	641.59985	0.0
1331.7000	1263.7000	1201.7998	1144.8999	1085.7998	1018.7000	1401.7000	0.0
1803.2000	1716.3999	1629.7998	1531.3999	1410.8499	1988.0999	1284.2998	0.0
2170.7998	2039.5999	1883.5000	1700.0000	2519.8999	2404.7998	2239.3999	0.0
2344.8499	2129.8999	1896.3999	3002.0999	2060.2998	2707.0999	2536.8999	0.0
2287.0099	2023.5999	3416.2998	3324.3999	3012.2998	2743.5999	2541.3999	0.0
2098.2000	3540.7998	3415.2998	3166.8999	2910.0000	2646.0999	2175.0999	0.0
3330.5000	5358.8999	3151.2000	2918.7000	2667.2998	2401.7000	2125.3999	0.0
3169.0006	2999.2000	2812.8999	2501.7998	2364.2000	2106.3999	0.0	0.0
2804.0099	2640.7600	2463.7000	2262.2000	2034.5999	0.0	3122.0999	0.0

TRHI= 0.0

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560.50000	744.50000	707.50000	667.50000	632.00000	601.89990	572.00000	0.0
1401.7000	1311.7000	1263.7000	1201.5999	1144.2000	1043.5000	1011.5000	0.0
1608.0099	1662.7998	1715.0000	1625.2000	1519.5000	1136.7000	0.0	0.0
2203.7998	2162.2998	2021.0999	1851.2000	1652.5999	2519.5999	0.0	0.0
2291.7998	2509.5000	2075.2000	1625.2000	2999.3999	2999.3999	2853.2998	0.0
2734.0000	2480.7998	2216.2998	1943.2000	3401.0999	3198.2998	2979.2998	0.0
2575.0099	2293.2998	2010.8999	0.0	3373.0000	3115.2000	2849.0000	0.0
2323.7998	2038.5000	3530.7000	3619.0000	3112.2998	2864.5999	2600.3999	0.0
2025.2000	3120.7000	3160.7000	3336.0999	2779.2998	2550.5000	2226.7000	0.0
0.0	2959.5000	2795.2998	2822.5999	2431.0000	2211.7998	1966.7000	0.0

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Figure III-22

CGSM INPUT - RAMJET FUEL SPECIFIC HEAT RATIO TABLES
(NAMSPH NAMELIST)

VARIABLE	DEFINITION
K3	Number of subtables input
KL(I), I=1,15	Number of entries per subtable
TT4A(I), I=1,15	Total temperature (one value for each table from 1 to K3)
FAR2(I,J), I=1,15, J=1,15	Fuel to air ratio for subtables I and columns J
*GAMLØ(I,J), I=1,15, J=1,15	Ratio of specific heats for low combustor pressure (for subtables I and columns J)
*GAMMED(I,J), I=1,15, J=1,15	Ratio of specific heats for medium combustor pressure (for subtables I and columns J)
*GAMHI(I,J), I=1,15, J=1,15	Ratio of specific heats for high combustor pressure (for subtables I and columns J)

- - - - - - - - - - - - - - - -

* GAMMED and GAMHI are used only if IFTYPE=1 in NAMELIST NAMRJS. Low, medium, and high pressures are set by PT41, PT42, and PT43 in NAMRJS.

NOTE: Prestored values are listed on facing pages. Table values not shown are zeros.

FIGURE III-22 (Continued)

Figure III-23

CGSM INPUT - RAMJET FUEL GAS CONSTANT TABLES

(NAMGSC NAMELIST)

VARIABLE	DEFINITION
K4	Number of subtables input
KN(I), I=1, 15	Number of entries per subtable
TT4B(I), I=1, 15	Total temperature (one for each table from 1 to K4)
FAR3(I,J), I=1, 15, J=1, 15	Fuel to air ratio for subtables I and columns J
*GASLØ(I,J), I=1, 15, J=1, 15	Gas constant at low combustor pressure for subtables I and columns J
*GASMED (I,J), I=1, 15, J=1, 15	Gas constant at medium combustor pressure for subtables I and columns J
*GASHI(I,J), I=1, 15, J=1, 15	Gas constant at high combustor pressure for subtables I and columns J

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* GASMED and GASHI are used only if IFTYPE = 1 in NAMELIST NAMRJS. Low, medium, and high pressures are set by PT41, PT42, and PT43 in NAMRJS.

NOTE: Prestored values are listed on facing pages. Table values not shown are zeros.

FIGURE III-23 (Continued)

Figure III-24

CGSM INPUT - RAMJET FUEL BURNER SEVERITY TABLES
(NAMBSP NAMELIST)

VARIABLE	DEFINITION
NB1	Number of data sets
BSP(I), I=1, 24	Burner severity parameter (BSP)
CØMEFF(I), I=1, 24	Combustion efficiency for each BSP
RLEAN(I), I=1, 24	Lean blow out ratio for each BSP

NOTE: Prestored values are listed on the facing page. Table
values not shown are zeros.

FIGURE III-24 (Continued)

FIGURE III-25

CGSM INPUT - AIR INLET PERFORMANCE AND SIZING DATA
(NAMINM NAMELIST)

VARIABLE	DEFINITION
	CRITICAL INLET PERFORMANCE MAP
K8	Number of pitch angles for which subtables are input [0]
KPTC(I), I=1,15	Number of Mach numbers entered in each subtable [15*0]
ALPHV(1), I=1,15	Pitch angles corresponding to each subtable [15*0. deg]
AAMACH(I,J), I=1,15, J=1,15	Mach numbers for subtables I and columns J [225*0.]
ADDD(I,J), I=1,15, J=1,15	Additive drag for subtables I and columns J [225*0]
AØACC(1,J) I=1,15, J=1,15	Mass flow ratio for subtables I and columns J [225*0.]
PT3PTØ(I,J), I=1,15, J=1,15	Combustor total pressure recovery for subtables I and columns J [225*0.]

	TWO-DIMENSIONAL INLET SIZING
ASPECT	Inlet aspect ratio - width divided by height measured in the capture plane [1.05]
DSHT	Inlet design altitude [10000. ft]
DSMACH	Inlet design Mach number [2.]
NDUCT	Duct material code [8]
NFRNG	Fairing material code [8]
NRAMP	Number of ramps in inlet design [3]
TFRNG	Inlet fairing thickness [.04 in.]
TSTART	Inlet wall thickness [.078 in.]

FIGURE III-25 (Cont'd.)

VARIABLE	DEFINITION

XC
YC

Scaling factors for the coordinate of the inlet cowl lip leading edge (L.E.). Its true coordinates are

$X = H*XC$, and
$Y = H*YC$,

where H is inlet height measured in the inlet capture plane. The origin of the coordinate system is generally set at the leading edge at the first compression ramp, with X being parallel to the missile centerline and Y being directed outward through the inlet center. (see diagram below) [0,0]

XR1
YR1

Scaling factors for the coordinates of the first compression ramp L.E. This is generally (0,0) since the origin is positioned at the first ramp L.E. [0,0]

XR2
YR2

Scaling factors for coordinates of the second compression ramp L.E. [0,0]

XR3
YR3

Scaling factors for coordinates of the third compression ramp L.E. [0,0]

XR4
YR4

Scaling factors for coordinates of the third compression ramp trailing edge. [0,0]

XT

Scaling factor for the inlet throat height, where the actual height is computed as $H_T = H*XT$, and H is inlet height measured in the capture plane [0]

YRANG1 First compression ramp angle [0. deg]

YRANG2 Second compression ramp angle [0. deg]

YRANG3 Third compression ramp angle [0. deg]

ZMACHT Inlet throat Mach number [0.0]

- - - - - - - - - - - - - - - - - - -

* Material codes include:

1 - AISI 150 psi steel
2 - AISI 200 psi steel
3 - 300 gr maraging steel
4 - 17-4 Ph stainless
5 - 2014-T6 aluminum

6 - AZ31B-0 magnesium
7 - 6AL-4V titanium
8 - Rene 41
9 - WC129Y Columbium
10 - Glass fabric epoxy laminate
11 - Filament wound glass epoxy

Note: Prestored values not listed are zeros.

Figure III-25 (Cont'd.)
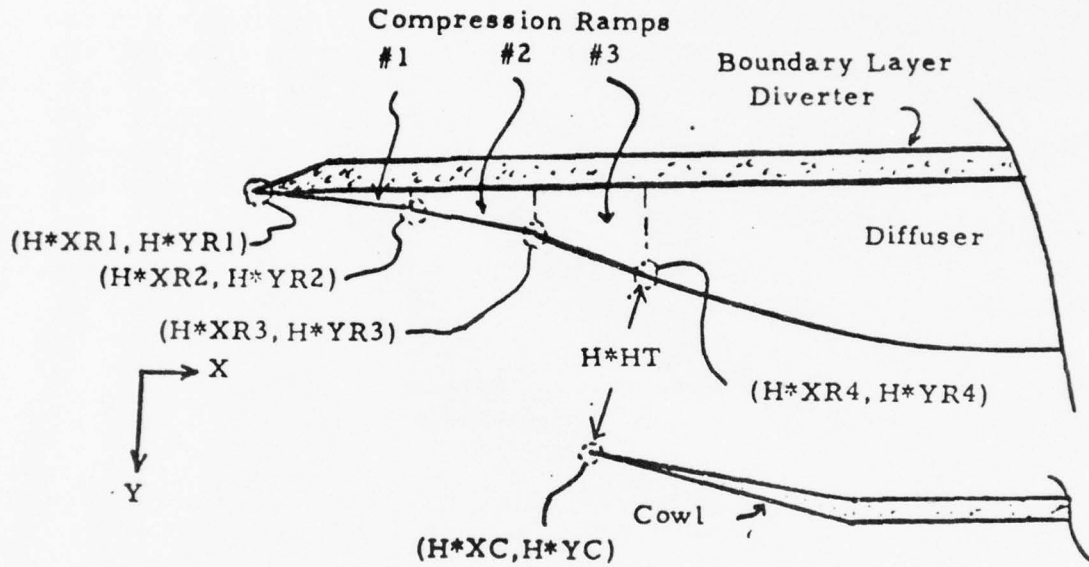
Compression Ramps
#1   #2   #3

Boundary Layer
Diverter

Diffuser

(H*XR1, H*YR1)

(H*XR2, H*YR2)

(H*XR3, H*YR3)

X

Y

H*HT

(H*XR4, H*YR4)

(H*XC, H*YC)

Cowl

INLET SIZING GEOMETRY

Figure III-26

CGSM INPUT - RELATIVE WORTH DATA
(NAM3 NAMELIST)

VARIABLE	DEFINITION
WØRTH1	Worth of the baseline missile configuration [100.]
NRMAX, PVRMAX(I), DWRMAX(I), I=1, 7	Sensitivity data defining the variation of worth with variable maximum missile range. The parameter NRMAX defines the number of data points input (NRMAX=7) for the PVRMAX and DWRMAX arrays. The PVRMAX array includes values of maximum range (n. mi.) while the DWRMAX array includes the change in worth (▲W for each PVRMAX value) relative to the baseline missile. [0, 7*0., 7*0.]
NWTWH, PVWTWH(I), DWWTWH(I), I=1, 7	Data defining relative worth dependency on warhead weight in lb. [0, 7*0., 7*0.]
NRCR, PVRCR(I), DWRCR(I), I=1, 7	Data defining relative worth dependency on cruise phase range in n. mi. [0, 7*0., 7*0.]
NRLL, PVRLL(I), DWRLL(I), I=1, 7	Data defining relative worth dependency on low-level run-in range in n. mi. [0, 7*0., 7*0.]
NHCR, PVHCR(I), DWHCR(I), I=1, 7	Data defining relative worth dependency on cruise altitude in feet [0, 7*0., 7*0.]
NHLL, PVHLL(I), DWHLL(I), I=1, 7	Data defining relative worth dependency on low-level run-in altitude in feet [0, 7*0., 7*0.]
NVCR, PVVCR(I), DWVCR(I), I=1, 7	Data defining relative worth dependency on cruise Mach number [0, 7*0., 7*0.]
NVLL, PVVLL(I), DWVLL(I), I=1, 7	Data defining relative worth dependency on low-level run-in Mach number [0, 7*0., 7*0.]

Figure III-26 (Continued)

VARIABLE	DEFINITION
NCEP, PVCEP(I) DWCEP(I), I=1,7	Data defining relative worth dependency on missile accuracy (CEP in n.mi.). [0,7*0.,7*0.]
NREL, PVREL(I) DWREL(I), I=1,7	Data defining relative worth dependency on missile flight reliability. [0,7*0.,7*0.]
NNØ, PVNØ(I), DWNØ(I), I=1,7	Data defining relative worth dependency on number of missiles (number per ship, number per aircraft, or number in force). [0,7*0.,7*0.]
ZCEP(I), I=1,10	Missile CEP array corresponding to the ZGWT array (used for a table look-up (TLU) of missile CEP for relative worth computations). [10*0.01 n.mi.]
ZFØRCE	Force size used in computing relative worth [100]
ZGWT(I), I-1,10	Guidance system weight data to be used in the TLU for CEP (corresponds to ZCEP array) [0,9*1000 lb]
ZREL	Flight reliability of the missile type to be generated [0.95]

Figure III-27

CGSM INPUT - BYPASS OPTIONS
(NAMBYP NAMELIST)

VARIABLE	DEFINITION

BYPASS CONTROL FLAGS

KBYDRG   Bypass option for aerodynamic computations [0]

= 0   Compute data
= 1   Bypass computation of aerodynamic tables and use input tables. Compute aero coefficients during ramjet sizing.
= 2   Bypass all aero computations and use input data

KBYPSM   Bypass option for propulsion system sizing [0]

= 0   Size a propulsion system for each concept
= 1   Bypass sizing and input propulsion terms

KBYVP   Bypass option for vehicle performance computation [0]

= 0   Compute performance for each concept
= 1   Bypass performance computation

KBYPAK   Bypass option for missile packaging test [1]

= 0   Test each concept against launcher packaging constraints
= 1   Bypass packaging test

PROPULSION BYPASS INPUT

ACA3   Ratio of capture area to ramjet combustor chamber area [0]

A5A3   Ratio of nozzle throat area to ramjet combustion chamber area [0]

A6A3   Ratio of nozzle exit area to ramjet combustion chamber area [0]

BEXIT   Booster nozzle exit area [0.0 sq. ft.]

BISPV   Booster vacuum Isp [0.0 sec.]

BOOWP   Booster propellant weight [0.0 lb.]

BTHVAC   Booster stage vacuum thrust [0.0 lb.]

DROPEB   Drop weight associated with external boosters [0 lb.]

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Figure III-27 (Cont'd.)

VARIABLE	DEFINITION
DROPST	General drop weight [0 lb.]
SEXIT	Sustainer nozzle exit area [0 sq. ft.]
SUSWP	Sustainer propellant weight [0.0 lb.]
TVACMN	Liquid or solid rocket sustainer minimum vacuum thrust [0.0 lb.]
TVACMX	Liquid/solid rocket sustainer maximum vacuum thrust [0.0 lb.]
XCGD1	Missile c.g. location measured in diameters from theoretical nose [5.]
XLBDY	Propulsion section length [0.0 in.] (See also SUPER NAMELIST in Figure III-26.)
XNØZ	Boattail section length [0.0 in.]
XTHRTL(I), I=1, 20	Throttle ratio for liquid/solid rocket sustainer defined by

$$XTHRTL = \frac{T - TVACMN}{TVACMX - TVACMN}$$

where T is a selected thrust level and $TVACMN \leqslant T \leqslant TVACMX$. [20*0.0]

YISP(I), I=1, 20	Specific impulse corresponding to each value of XTHRTL(I) [20*0.0 sec.]

*AERO BYPASS DATA - USED FOR TRAJECTORY SIMULATION

SMACH1(I) CLALF1(I) I=1, 20	Lift coefficient table (Mach number versus $C_{L\alpha}$) to be used when NAERØ=1 in NAMVPM for a given trajectory phase.
SMACH2(I), CLALF2(I), I=1, 20	Lift table used when NAERØ=2.
SMACH3(I), CLALF3(I), I=1, 20	Lift table used when NAERØ=3.
SMACH4(I), CLALF4(I), I=1, 20	Lift table used when NAERØ=4.

Figure III-27 (Cont'd.)

VARIABLE	DEFINITION
SMACH5(I), CLALF5(I) I-1, 20	Lift table used when $NAER\emptyset=5$.
DMACH1(I), $CD\emptyset1(I,J)$, I=1, 20; J=1, 5	Drag coefficient table (Mach number and altitude versus C_{D_o}) used when $NAER\emptyset=1$ in NAMVPM for a given trajectory phase. DMACH1 is prestored as identical to SMACH1. $CD\emptyset1$ is loaded in a specialized table format where $CD\emptyset1$ (I,J), J=1,5, is a set of altitudes, and $CD\emptyset1$ (I,J), I=2, 20, J=1, 5 is a set of C_{D_o} values corresponding to those altitudes and DMACH1 values.
DMACH2(I), $CD\emptyset2(I,J)$ I=1, 20; J=1, 5	Drag table used when $NAER\emptyset=2$.
DMACH3(I), $CD\emptyset3(I,J)$, I=1, 20; J=1, 5	Drag table used when $NAER\emptyset=3$.
DMACH4(I), $CD\emptyset4(I,J)$, I=1, 20; J-1, 5	Drag table used when $NAER\emptyset=4$.
DMACH5(I), $CD\emptyset5(I,J)$, I=1, 20; J=1, 5	Drag table used when $NAER\emptyset=5$.

AERO BYPASS DATA - USED FOR RAMJET SIZING

CD$\emptyset$DES	Drag coefficient (less inlet drag contribution) used for designing air breathing missiles when KBYDRG=2 [0.0]
CLADES	Lift coefficient ($C_L\alpha$), used when KBYDRG=2 for designing air breathing missiles (less inlet lift term) [0.0 per degree]

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* Aero bypass tables have default values of 0.0 and take the form (for each NAERO value):

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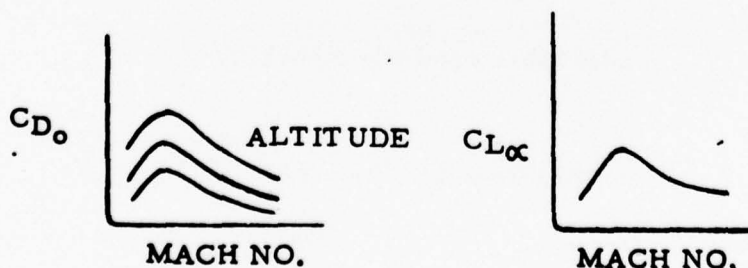
Figure III-28

CGSM INPUT - TRAJECTORY CONTROL TERMS
(NAMVPM NAMELIST)

VARIABLE   DEFINITION

PHASE PARAMETERS

ALPMAX(I), I=1, 20   Maximum angle of attack in degrees [20*0.]
                      where I designates a trajectory phase.
                      Maximum α (see note below) must be selected
                      to satisfy stability and control constraints, inlet
                      performance limits, and flight path control require-
                      ments. Input of a small ALPMAX may affect the
                      trajectory linearization for a given phase, since
                      that linearization uses the smaller of DALPH (see
                      below) and ALPMAX for each phase.

ALTF(I), I=1, 20   Phase reference altitude in feet [20*0.].
                      For constant altitude phases, ALTF should be
                      input as desired cruise altitude. For climb or
                      dive phases, ALTF should be the desired level-
                      off altitude. For other phase types, ALTF is the
                      desired end of phase altitude.

ANZMAX(I), I=1, 20   Maximum load factor in g's [20*0.].
                      This parameter is selected based on expected
                      phase maneuvering and is constrained by stability
                      and control requirements.

COND1(I), COND2(I),   Dependent variable used with the ICONT option for
. . . , COND20(I),   flight path control, where COND1 applies to phase 1,
I=1, 10   COND2 applies to phase 2, etc. All array values
                      are prestored as zero.

CONI1(I), CONI2(I),   Independent variable used with the ICONT option for
. . . , CONI20(I),   flight path control, where CONI1 applies to phase 1,
I=1, 10   etc. All values are prestored as zero.

FVALUE(I),   Final value of phase termination parameter desig-
I=1, 20   nated by ITERM [20*0]

GAMMAF(I),   Approximate end-of-phase flight path angle used in
I=1, 20   thrust computations. [20*0. deg]

ICONT(I),   Flight path control option parameter. [20*0]
I=1, 20
                      = 1 Path controlled by a TLU of time in sec. versus
                           path angle (γ) in degrees, where time is the
                           independent parameter (input through CONI1,
                           CONI2,...) and path angle is the dependent

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Figure III-28 (Cont'd.)

VARIABLE

DEFINITION

parameter (input through $C\emptyset ND1, C\emptyset ND2, \ldots$).
This option is available for boost phases, and
for sustainer phases if $M\emptyset DES=\pm 1$.

= 3 Path controlled by a TLU of time $(CONI_i)$ in
seconds versus pitch attitude (ω) in degrees
$(C\emptyset ND_i)$. This option is available for boost
phases and sustainer phases where $M\emptyset DES=\pm 1$.

= 4 Path controlled by a TLU of altitude in feet
$(C\emptyset NI_i)$ versus θ in degrees $(COND_i)$. This
option is available for boost phases and for
sustainer phases where $M\emptyset DES=\pm 1$.

= 5 Path controlled by a TLU of Mach number
$(CONI_i)$ versus θ in degrees $(COND_i)$. This
option is available for all boost phases and for
sustainer phases where $M\emptyset DES=\pm 1$.

= 6 Path controlled by a TLU of time in seconds
$(CONI_i)$ versus angle of attack (α) in degrees
$(COND_i)$. This option is available for sustainer
phases if $MODES=\pm 1$ and for all boost phases.

=7 Path controlled by a TLU of altitude in feet
$(CONI_i)$ versus α in degrees $(COND_i)$. This
option is available for sustainer phases if
$MODES=\pm 1$ and for all boost phases.

=8 Path controlled by a TLU of Mach number $(CONI_i)$
versus α in degrees $(COND_i)$. This option is
available for sustainer phases if $MODES=\pm 1$
and for all boost phases.

= 9 Path controlled by a TLU of time in seconds
$(C\emptyset NI_i)$ versus normal load factor in g units
$(COND_i)$. This option is available for sus-
tainer phases if $M\emptyset DES=\pm 1$ and for all boost
phases.

= 10 Path controlled by a TLU of altitude in feet
$(CONI_i)$ versus normal load factor in g units
$(COND_i)$. This option is available for sustainer
phases if $M\emptyset DES=\pm 1$ and for all boost phases.

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Figure III-28 (Cont'd.)

VARIABLE	DEFINITION

= 11 Path controlled by a TLU of Mach number (CONI$_i$) versus normal load factor in g units (COND$_i$). This option is available for sustainer phases if MØDES=+1 and for all boost phases.

= 12 Path controlled by a TLU of altitude (in feet) versus Mach number. If MHGEN=0, altitude and Mach number must be input through CONI$_i$ and COND$_i$. If MHGEN >0, those altitude and Mach number data arrays are computed internally. This option is available for any sustainer phase (when MØDES=±1) and for any MHGEN. The option is available for boost phases only when MHGEN=0, however.

= 13 Path controlled to maintain a constant altitude cruise at a Mach number set by XMACHF. Phase start is at $\mathcal{T}$ =0 regardless of previous phase termination conditions. This option is available only for sustainer phases and MODES must be zero.

= 14 Path controlled to force the missile to level off at an altitude set by ALTF, at a Mach number set by XMACHF, and at a path angle set by GAMMAF (GAMMAF should be zero). The phase preceding the level-off must be a climb or dive maneuver terminated with ITERM=7. The level-off phase should be terminated at zero flight path angle using ITERM=1.

Input of ICONT=1,3,4,..., or 11 requires input of corresponding CONI$_i$ and COND$_i$ arrays. Those arrays are not required if ICONT is 13 or 14, and are not required if ICONT=12 and MHGEN=1.

IPTYPE(I), I=1,20	Propulsion system type [20*0]

= 0 Unpowered
= 1 Solid boost stage
= 2 Liquid boost stage
= 3 Solid or liquid sustainer stage
= 4 Ramjet sustainer stage
= 5 Turbojet sustainer stage

ITERM(I), I=1,20	Phase termination option [20*0]

Figure III-28 (Cont'd.)

VARIABLE
DEFINITION

= 1   When phase is to be terminated on a flight path angle (γ) set by FVALUE (FVALUE in degrees).

= 2   When phase is to be terminated on a velocity set by FVALUE (ft/sec)

= 3   When phase is to be terminated on an altitude set by FVALUE (ft)

= 4   When phase is to be terminated on a phase range set by FVALUE (n.mi.). If the phase is an iterative cruise phase (see ICØNT and NCPHAZ), FVALUE should be a first guess at maximum cruise range, if maximum cruise range is known with some degree of confidence. If maximum cruise range is not known, FVALUE should be input as a small value (several miles). If a range is input which is too large, the cruise iteration may burn missile inert weight as propellant in an attempt to salvage the iteration. If instantaneous weight should then drop below 10 percent of design inert weight, a fatal error is assumed, and the trajectory will be terminated.

= 5   When phase is to be terminated on a pitch attitude (θ) set by FVALUE (degrees)

= 6   When phase is to be terminated on an instantaneous propellant weight (fuel remaining) set by FVALUE (FVALUE in pounds). Propellant to be book-keeped is set by IPTYPE.

= 7   When phase is to be terminated on a level-off load factor set by FVALUE (g's). During a climb or dive phase which is to be followed by a level-off phase, ITERM=7, and FVALUE is a predicted load factor for completing a level-off at the desired altitude (ALTF) and Mach number (XMACHF). FVALUE is in g units and is measured normal to the body roll axis. Load factor is assigned a positive value when the missile is "pulling up" and a negative value when "pulling down".

Figure III-28 (Cont'd.)

VARIABLE	DEFINITION

= 8 When the phase is to be terminated on a
Mach number set by FVALUE.

= 9 When the phase is to be terminated on a total
range set by FVALUE (n. mi.)

ITERM must be coordinated with FVALUE and also
with SLOPE.

MHGEN(I),
I=1, 20

Option to generate climb schedule [20*0]

= 0 For no climb schedule generation
= 1 To generate a schedule of Mach number versus
altitude

The option of MHGEN(I)=1 is designed for climb
phases when ICONT(I)=12. For such phases, the
program computes and stores a schedule of altitude
vs. Mach number which satisfies input values of
ALTF, XMACHF, GAMMAF, and FVALUE.

MØDES(I),

Sustainer thrust control option [20*0]

= 1   For maximum thrust
= 0   For thrust as required (cruise or level-off)
= -1 For minimum thrust

MØDES(I) must be input as ± 1 when ICØNT(I) has a
value of 12 or less. When ICØNT(I) is 13 or 14,
MØDES(I) must be zero. This parameter is ignored
during boost phases.

NAERO(I),
I=1, 20

Aerodynamics table option flag. If KBYDRG=0 in
NAMBYP, lift and drag tables are generated internally
and are accessed by setting NAERØ(I)=1 (for boost
phases) or NAERØ(I)=2 (for sustainer phases).

If KBYDRG=1 in NAMBYP, lift and drag tables are input
through NAMBYP, and NAERØ(I) designates which
set is to be used for each phase. For example, if
KBYDRG=1 and NAERO(I)=2, the CGSM uses drag/
lift data from DMACH2, CDO2, SMACH2, and
CLALF2 for the Ith phase [20*0]

Figure III-28 (Cont'd.)

VARIABLE	DEFINITION

SLØPE(I),
I=1, 20

Sign of dependent variable (FVALUE) time rate of change at termination [20*0]

= 0 Termination occurs regardless of time rate sign
= 1 Terminate only if time rate is positive
= -1 Terminate only if time rate is negative

TPHASE(I),
I=1, 20

Upper limit on time spent in a given phase. If elapsed phase time exceeds TPHASE(I), the phase is terminated and the integration proceeds to the next phase. [20*10000. sec]

TTØTAL(I),
I=1, 20

Upper limit on elapsed time from launch (includes TIMEI below) for a given phase. If elapsed time exceeds TTØTAL(I) for phase I, that phase is terminated and the integration proceeds to the next phase. [20*10000. sec]

XMACHF(I),
I=1, 20

Phase reference Mach number [20*0.0]. For constant altitude cruise phases, XMACHF is the desired cruise Mach number. During climb or level off, XMACHF is the desired cruise Mach number. During climb schedule generation when ICONT(I)=12 and MHGEN(I)=1, XMACHF is used as the upper limit on the climb Mach number and XMACHF/2 is used as the lower limit. XMACHF is the desired final Mach number for all other phases.

ZPRINT(I),

Print interval for each phase [20*0. sec]
If ZPRINT(I) is input as zero, the print interval is selected internally according to detected integration errors.

SINGLE VALUE CONTROL PARAMETERS

ALTI

Initial altitude [0.0 ft.]

DALPH

Attitude (α) range within which ramjet propulsion performance characteristics are linearized. Small values increase accuracy of propulsion data at the expense of computer execution time (see also ALPMAX above) [.035 rad]

DALT

Altitude (h) range within which ramjet propulsion performance characteristics are linearized. Small values increase accuracy of propulsion data at the expense of computer execution time. [10000 ft.]

Figure III-28 (Cont'd.)

VARIABLE	DEFINITION
DCFN	Net thrust coefficient (C_{FN}) range within which ramjet propulsion characteristics are linearized. Small values increase accuracy of propulsion data at the expense of computer execution time. Applies only to phases where MODES=0. [0.1]
DELMAX	Maximum integration step size [60. sec]
DHCL	Altitude step used in internal generation of climb schedule (used if ICØNT=12 and MHGEN=1 for a given phase) [10000. ft]
DMACH	Mach number (M) range within which ramjet propulsion performance characteristics are linearized. Small values increase accuracy of propulsion data at the expense of computer execution time [0.40]
DMIN	Minimum continuous integration interval [.001 sec]
DSTART	Starting integration interval [0.1 sec]
DVCL	Velocity step used in internal generation of climb schedule (used if ICØNT=12 and MHGEN=1 for a given phase) [100. ft/sec]
EREF	Reference value of normalized truncation error [5E-4]
ERRFAC	Factor on EREF by which the truncation error may exceed the reference value [5.]
FARMAX	Maximum ramjet fuel/air ratio used during trajectory computations [0]
GAMMAI	Initial flight path angle [0 deg.]
GKG	Guidance path angle error gain [1.0]
GKV	Guidance velocity error gain [0.001]
GKVCRU	Cruise velocity error gain [0.1]
GTØPT	Guidance table time option [1.0]
MOPT	Initial velocity option flag [1]
	= 0 When initial velocity is input through VELI in ft/sec
	= 1 When initial velocity is input through XMACHI in Mach
NCPHAZ	Trajectory cruise phase number [0]

Figure III-28 (Cont'd.)

VARIABLE	DEFINITION
NDPHAZ	Phase at start of which weight is dropped [0]
NLPHAZ	Total number of trajectory phases [0]
RANGEI	Initial range [0.0 n. mi.]
RTØL	Tolerance on iteration for maximum range. Cruise range (phase specified by NCPHAZ) is varied until fuel exhaustion is enforced at end of final trajectory phase (set by NLPHAZ). The actual error will be much less than RTØL. [10. n. mi.]
TIMEI	Initial time [0.0 sec]
TPCMGN	Ramjet propulsion system pressure margin to be used during trajectory integration. [3.]
TT4MAX	Maximum ramjet combustion temperature used during trajectory computations [3900°R]
VELI	Initial launch velocity in ft/sec. used if MOPT=0 [0.0 ft/sec]
XMACHI	Initial launch velocity in Mach used if MOPT=1 [0.0]

- -
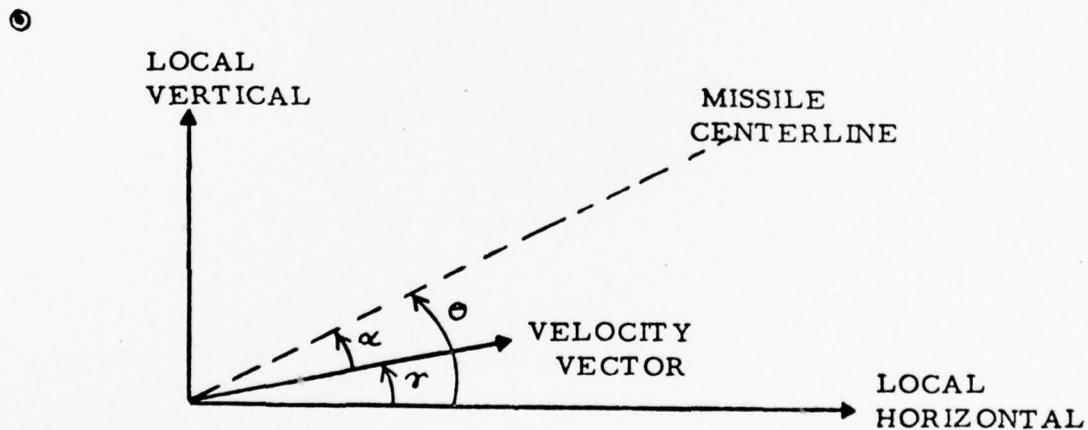
Figure III-29

CGSM INPUT - SUPERVISORY LIST
(SUPER NAMELIST)

VARIABLE	DEFINITION
*ALTI	Initial altitude [0.0 ft.]
ART	Exposed aspect ratio of two tail panels [2.57]
BCANTA	External booster cant angle [0 deg.]
BRAT	Nose bluntness ratio (nose radius/missile radius) [0]

DIAFR — External booster diameter fraction, required since external diameter is computed as:

$$DEXT = (missile\ diameter) \times (DIAFR).$$

Each external booster has diameter DEXT. [prestored as = 1.0]

DVMULT — Multiplier used in the booster ΔV iteration [1.1] The first guess at booster ideal velocity is computed as:

$$V_I = DVMULT*(VEOB-VL)$$

where VEØB and VL are defined below. DVMULT can be refined on successive jobs during an analysis to improve the accuracy of the first guess and reduce the number of iterations.

DVTOL — Tolerance used in the iteration on booster delivered ΔV [20 ft/sec.]

*FARMAX — Maximum ramjet fuel/air ratio used during trajectory computations [0]

FINE — Theoretical nose fineness ratio [2.5]

FRBT — Boattail fineness ratio (boattail segment length/ missile diameter) [0]

*GAMMAI — Initial flight path angle [0 deg.]

IART — Tail arrangement option [4]

= 1 Planar ⊥
= 2 Cruciform +
= 3 Triform 人
= 4 Cruciform ✕

Figure III-29 (Cont'd.)

VARIABLE   DEFINITION

If IART=1, tail area is allocated to the vertical and horizontal panels using VTALOC (from NAMCNF). In that case, vertical tail area is set by VTALOC times total area, and the remainder is split equally between the two horizontal panels.

IARW   **Wing arrangement** [0]

                = 0 For no wings o
                = 1 For planar wing -O-
                = 4 For cruciform wing ⋉

IBTL   Boattail code [0]

                = 0 No boattail
                = 1 Conical boattail

ICNTRL   Control selection code [1]

                = 1 Tail control
                = 2 Wing (canard)

INWØRL   Option for basic variable number "17" [0]

                = 0 For input of missile weight variations
                = 1 For input of missile length variations

ISURFT   Tail type [1]

                = 1 Trapezoidal
                = 2 Delta

ISURFW   Wing type [1]

                = 1 Trapezoidal planform
                = 2 Delta planform

ITHR   Option for basic variable number 9 (used only for solid and liquid rocket cruise missiles) [0]

                = 0 For input of design vacuum thrust
                = 1 For input of design vacuum thrust-to-weight ratio

Figure III-29 (Cont'd.)
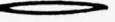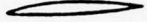
VARIABLE	DEFINITION

ITN   Nose shape options [2]

                = 1   Tangent ogive
                = 2   Von Karman
                = 3   Cone
                = 4   Hemisphere
                = 5   Blunted cone
                = 6   Blunted ogive

ITSECT   Tail section [1]

                = 1   Double wedge
                = 2   Bi-convex
                = 3   Modified double wedge

IWSECT   Wing section [1]

                = 1   Double wedge
                = 2   Bi-convex
                = 3   Mod double wedge

KINLET   Inlet type [2]

                = 1   Single belly mounted
                = 2   Dual side mounted
                = 4   Four sided mounted

KPRØP   Propulsion system option [41]

                = 10   For solid rocket
                = 13   For solid rocket with external solid boosters
                = 20   For liquid rocket
                = 23   For liquid rocket with external solid boosters
                = 41   For ramjet with integral solid booster
                = 43   For ramjet with external solid boosters
                = 44   For non-boosted ramjet
                = 50   for turbojet
                = 53   for turbojet with external solid boosters

MAXNIT   Maximum number of iterations allowed for convergence on booster delivered ΔV [5]

*MOPT   Initial velocity option flag [1]

                = 0   When initial velocity is input through VELI in ft/sec
                = 1   When initial velocity is input through XMACHI in Mach

*NCPHAZ   Trajectory cruise phase number [0]

Figure III-29 (Cont'd.)

VARIABLE	DEFINITION
*NDPHAZ	Phase at start of which weight is dropped [0]
*NLPHAZ	Total number of trajectory phases [0]
NW	Wing Code [0]
	= 0 No wings designed or sized = 1 Wings designed and sized
NZLLRI	Phase number for output on LLRI range, altitude, and speed [0]
NZTEMP	Ramjet combustor temperature option [0]
	= 0 Size to a fixed TT4 value = 1 Step TT4 if required using DELT4 from NAMRJS
*TPCMGN	Ramjet propulsion system pressure margin to be used during trajectory computations [3.]
*TT4MAX	Maximum ramjet combustion temperature used during trajectory computations [3900°R]
*VELI	Initial launch velocity in ft/sec used if MOPT=0 [0.0 ft/sec]
VEØB	Velocity required at end of boost phase [2578 ft/sec]
VL	Velocity at start of boost phase [861.9 ft/sec]
WMISC	Miscellaneous payload weight [0.0 lb]
XLBDY	First guess at propulsion section length, used for initial aerodynamics computations for ramjet missiles, when sizing to a weight. A built-in approximation will be used if XLBDY is input as zero [0. in.]
*XMACHI	Initial launch velocity in Mach used if MOPT=1 [0]
ZXNB	Number of external boosters [2]

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* These parameters appear in both NAMVPM and SUPER. They are intended to be input through NAMVPM in the general case, but may be input through SUPER for stacked cases in a given job. If multiple trajectories are requested, these parameters must always be input through NAMVPM.

FIGURE III-30

CGSM INPUT - SCREENING TERMS
(NAMSCR NAMELIST)

VARIABLE	DEFINITION
LEVELS	Number of levels to be identified in the screening process [10]
NCØUT	Number of top level concepts for which output is required [10]
NLØUT	Number of levels for which output is required [1]

4.0   RCM INPUT DESCRIPTION

Input to the Relative Cost Model (RCM) of the CGSM is divided into three categories and into six NAMELIST lists. The first category of input includes those parameters which are required input for the computation of cost terms in the course of generating and screening missile concepts. Those inputs are contained in the NAMCST NAMELIST list (see Figure III-31 at the end of this section). The second category of input includes all parameters required to compute cost in a "stand-alone" fashion without first generating concepts. Those inputs are listed under NAMCBY (see Figure III-32). The third category -- complete sets of cost estimating relationship (CER) coefficients and multipliers -- is controlled by the user through the NAMCNP, NAMCCN, NAMCPS, and NAMCCP lists. Those lists are defined in Figures III-34 through III-35. Each input list is discussed further in the following sections.

4.1   NAMCST DESCRIPTION

Subsystem, system, and total missile cost can be computed in the RCM for each missile concept as it is generated, and total cost can be filed for subsequent use in concept screening. Most parameters required for those cost computations are computed within the various CGSM sizing and performance models; however, certain parameters are assumed to be input directly by the user. Those parameters are assigned to the NAMCST list (Figure III-31). That list includes guidance and controls system type and performance parameters, guidance weight, and screening options. Default values are assigned to each parameter, as is listed on Figure III-31.

4.2   NAMCBY DESCRIPTION

The RCM can be exercised within the CGSM in much the same manner as a stand-alone program. The CGSM user is provided routinely with bypass options as a means of conserving data setup time and computer time requirements for those JOBs in which the complete concept generation

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and screening process is not required. Exercising the RCM alone requires input of the NAMCBY list (see Figure III-32) along with the NAMCST list (Figure III-31) and input of a "ZIP 11 4" card (see Section III-1.0). Since missile sizing and performance steps normally exercised in the CGSM are bypassed by this procedure, all cost parameters which would have been computed in those steps must be input by the user. The NAMCBY list is made up of those "bypassed" parameters. Specific input required is heavily dependent on propulsion system type, as is shown in Figure III-33. The parameters, KA, KC, KG, KP, and KW, can be input as equal to one to suppress computation of selected cost terms. That suppression can further reduce input requirements.

4.3 NAMCNP, NAMCCN, NAMCPS, AND NAMCCP DESCRIPTION

Each RCM CER can be modified through input to the extent of changing complexity factors, inflation factors, miscellaneous costs, and coefficients. Each CER is described in Volume V and each input item in the NAMCNP list is correlated to a CER in that volume. The NAMCNP list (see Figure III-34) includes all inflation factors, complexity factors, profit margins, and miscellaneous costs for all non-propulsion systems (airframe and integration, guidance, controls, and warhead). The NAMCCN list (see Figure III-35) includes all CER coefficients for those non-propulsion systems. Propulsion system CER inflation factors, complexity factors, profit margins, and miscellaneous costs are input through the NAMCPS list (see Figure III-36). Propulsion system CER coefficients are input through the NAMCCP list (see Figure III-37). Default values are listed on Figures III-34 and III-36 for the CER multipliers; however, default values for the CER coefficients are defined in Volume V only.

FIGURE III-31

CGSM INPUT - RCM DATA
(NAMCST NAMELIST)

VARIABLE	DEFINITION
BSP	Spectral bandwidth used in the IR guidance system [0.0 μ M]
FC	Center frequency [10.0 GHz for active or passive/semi-active or 10.0 μ M for IR type systems]
ICTYPE	Control system type selector [1] = 1 with autopilot = 2 without autopilot
IYEAR	Calendar year for which cost data are to be computed [1974]
KAGATE	Guidance angle gating option flag [0] = 1 for systems where angle gating is used = 0 for systems where angle gating is not used
KFUZE	Warhead fuzing selection flag [0] = 0 for contact fuze = 1 for proximity fuze
KGAIN	Controls system adaptive gain (dither) flag [0] = 1 for systems where adaptive gain is used = 0 for systems where adaptive gain is not used
*KGTABL	Control flag used to set guidance parameters (BSP, FC, KAGATE, KSGATE, KSTAB, NCHAN, NDET, and PPEAK) internally [1] = 1 to set parameters according to WTGUID and KGTYPE = 0 to use direct input of guidance parameters
KGTYPE	Control flag used to set guidance system type [11] = 11 for passive/semi-active (I band) = 12 for passive/semi-active (J band) = 21 for active (magnetron) (I band) = 22 for active (magnetron) (J band) = 31 for IR
KSGATE	Guidance speed gating option [0] = 1 for systems where speed gating is used = 0 for systems where speed gating is not used
KSTAB	Guidance stabilization option flag [0] = 1 for systems stabilized in place = 0 for systems not stabilized

FIGURE III-31 (Cont'd.)

VARIABLE	DEFINITION
NCHAN	Number of doppler channels (used for guidance systems where KSTAB=1) [0]
NDET	Number of detectors used in the IR guidance system [0]
NSCØST	Selection flag for screening cost [1] = 1 screen on first unit production cost = 2 screen on RDT&E cost = 3 screen on RDT&E plus production cost
NSCRC	Screening parameter selection flag [0] = 0 screen on cost according to NSCØST = 1 screen on missile weight
PPEAK	Peak generated transmit power [0.0 kilowatts]
R	Rate at which missiles are produced [1.0 per mo.]
QD	Number of missiles produced during the RDT&E phase [20.]
WTGUID	Guidance system weight [0.0 lb.]

FIGURE III-31 (Cont'd.)

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* Input of KGTABL=1 directs the CGSM to set BSP, FC, KAGATE, KSGATE, KSTAB, NCHAN, NDET, and PPEAK according to the following table:

PARAMETER	DEFAULT VALUE														
	KGTYPE=1			KGTYPE=12			KGTYPE=21			KGTYPE=22			KGTYPE=31		
WTGUID	50	100	150	50	100	150	150	250	350	150	250	350	25	50	100
BSP													2	2	6
FC	10	9	8	20	15	10	9	9	9	15	15	15	2.3	5	11
KAGATE	0	0	0	0	0	0	0	0	0	0	0	0			
KSGATE	0	0	0	0	0	0	0	0	0	0	0	0			
KSTAB	0	0	0	0	0	0	0	0	0	0	0	0			
NCHAN	0	0	0	0	0	0	0	0	0	0	0	0			
NDET													1	1	1
PPEAK							40	150	250	40	150	250			

FIGURE III-32

CGSM INPUT - RCM BYPASS DATA
(NAMCBY NAMELIST)

VARIABLE	DEFINITION
A	Missile weight less propulsion system, warhead, guidance, and control systems [1000. lb.]
*CASEM	External booster case (or integral ramjet combustor) material code [0]
D	Missile diameter [0.0 in.]
DCØM	Ramjet combustion chamber diameter [0.0 in.]
DP	Solid rocket motor case insulation volume [0.0 cu. in.]
DTHRT	External booster nozzle throat diameter [0.0 in.]
FMAX	Liquid rocket design maximum thrust [0 lbf]
FNET	Turbojet design thrust (sea-level static thrust) [0 lbf]
GGW	Weight of the gas generator used in the ramjet pressurization system (used only if KFM=3) [0 lb.]
HPPUMP	Horsepower of the ramair turbine used in the ramjet pressurization system (used only if KFM=4) [0 Hp]
KA	Control parameter used to bypass airframe and integration costing [0] = 0 compute cost of airframe and integration = 1 bypass costing
KC	Control parameter used to bypass controls costing [0] = 0 compute controls cost = 1 bypass costing
KFM	Ramjet fuel management (pressurization) system control parameter = 1 for N_2 stored gas = 2 for LGG (liquid gas generator) = 3 for SGG (solid gas generator) = 4 for ramair turbine
KG	Control parameter used to bypass guidance system costing [0] = 0 compute guidance cost = 1 bypass costing

FIGURE III-32 (Cont'd.)

VARIABLE	DEFINITION

KINDPS — Propulsion system option [41]
= 10 for solid rocket
= 13 for solid rocket with external solid boosters
= 20 for liquid rocket
= 23 for liquid rocket with external solid boosters
= 41 for ramjet with integral solid boosters
= 43 for ramjet with external solid boosters
= 44 for non-booster ramjet
= 50 for turbojet
= 53 for turbojet with external solid boosters

KP — Control parameter used to bypass propulsion system costing [0]
= 0 compute propulsion system cost
= 1 bypass costing

KW — Control parameter used to bypass warhead costing [0]
= 0 compute warhead cost
= 1 bypass costing

*MATTK — Ramjet fuel tank material code [0]

METAL — Liquid rocket tank material code [0]
= 1 for aluminum
= 2 for titanium
= 3 for steel

METTJ — Turbojet tank material code [0]
= 1 for aluminum
= 2 for titanium
= 3 for steel

MP — External or integral booster propellant weight [0.0 lb.]

NØZWT — Total nozzle weight for integral ramjets or external booster nozzle weight (per booster motor) [0.0 lb.]

RNØZI — External booster nozzle inlet radius [0.0 in.]

R5 — Ramjet nozzle throat radius [0.0 in.]

S — Airframe design speed [1000 knots]

SDTHRT — Solid rocket nozzle throat diameter [0.0 in.]

SRNØZI — Solid rocket nozzle inlet radius [0.0 in.]

SWM — Solid rocket motor weight [0.0 lb.]

FIGURE III-32 (Cont'd.)

VARIABLE	DEFINITION
SWMC	Solid rocket motor case weight [0.0 lb.]
T4	Turbojet design turbine inlet temperature [0.0 °R]
VBI	External booster case or integral booster combustor insulation volume [0.0 cu. in.]
VCØMI	Non-integral ramjet combustor insulation volume [0.0 cu. in.]
VEXIN	Ramjet tank external insulation volume [0.0 cu. in.]
VGT	Liquid rocket pressurization gas storage bottle volume [0.0 cu. in.]
VREQ	Nitrogen tank volume for the ramjet pressurization system [0.0 cu. in.]
WCØMM	Non-integral ramjet combustor metal weight [0.0 lb.]
WCS	Control system cost [0.0 lb.]
WF	Liquid rocket fuel weight [0.0 lb.]
WGG	Liquid rocket gas generator weight [0.0 lb.]
WLV	Liquid rocket miscellaneous hardware weight [0.0 lb.]
WM	External booster motor weight [0.0 lb.]
WMC	External or integral booster case weight [0.0 lb.]
WN	Solid rocket nozzle weight [0.0 lb.]
WNØZ	Non-integral ramjet nozzle weight [0.0 lb.]
WØ	Liquid rocket oxidizer weight [0.0 lb.]
WP	Solid rocket propellant weight or liquid rocket fuel plus oxidizer weight [0.0 lb.]
WSC	Liquid rocket start cartridge weight [0.0 lb.]
WT	Turbojet or liquid rocket tank weight [0.0 lb.]
WTANK	Ramjet fuel tank weight [0.0 lb.]
WTC	Liquid rocket thrust chamber weight [0.0 lb.]
WTFUEL	Ramjet fuel weight [0.0 lb.]
WTP	Liquid rocket turbopump weight [0.0 lb.]

FIGURE III-32 (Cont'd.)

VARIABLE	DEFINITION
WWH	Warhead weight [0.0 lb.]
YI	Ramjet nozzle inlet radius [0.0 in.]
ZXNB	Number of external boosters [0]

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* Material codes include:

    1 - AISI 150 psi steel
    2 - AISI 200 psi steel
    3 - 300 gr maraging steel
    4 - 17-4 Ph stainless
    5 - 2014-T6 aluminum
    6 - AZ31B-0 magnesium
    7 - 6AL-4V titanium
    8 - Rene 41
    9 - WC129Y Columbium
   10 - Glass fabric epoxy laminate
   11 - Filament wound glass epoxy

FIGURE III-33

BYPASS INPUT REQUIRED FOR CGSM RCM

PROPULSION SUBSYSTEM	INPUT PARAMETERS REQUIRED FOR BYPASS
LIQUID ROCKET	A, FMAX, METAL, VGT, WF, WGG, WLV, WØ, WP, WSC, WT, WTC, WTP
BOOSTED LIQUID ROCKET	A, FMAX, METAL, VGT, WF, WGG, WLV, WØ, WP, WSC, WT, WTC, WTP, CASEM, D, DIAFR, DTHRT, MP, NØZWT, RNØZI, VBI, WM, WMC, ZXNB
SOLID ROCKET	A, D, DP, SDTHRT, SRNØZI, SWM, SWMC, WN, WP
BOOSTED SOLID ROCKET	A, D, DP, SDTHRT, SRNØZI, SWM, SWMC, WN, WP, CASEM, DIAFR, DTHRT, MP, NØZWT, RNØZI, VBI, WM, WMC, ZXNB
INTEGRAL RAMJET*	A, CASEM, DCØM, GGW, HPPUMP, KFM, MATTK, MP, NØZWT, R5, VBI, VEXIN, VREQ, WMC, WTANK, WTFUEL
NON-BOOSTED RAMJET *	A, CASEM, DCØM, GGW, HPPUMP, KFM, MATTK, R5, VCØMI, VEXIN, VREQ, WCØMM, WNØZ, WTANK, WTFUEL, Y1
EXTERNALLY-BOOSTED RAMJET*	A, CASEM, DCØM, GGW, HPPUMP, KFM, MATTK, R5, D, DIAFR, DTHRT, MP, NØZWT, RNØZI, VBI, WM, WMC, ZXNB
TURBOJET	A, FNET, METTJ, T4, WF, WT
BOOSTED TURBOJET	A, FNET, METTJ, T4, WF, WT, CASEM, D, DIAFR, DTHRT, MP, NØZWT, RNØZI, VBI, WM, WMC, ZXNB

* Of the ramjet inputs, VREQ is required only if KFM=1, GGW is required only if KFM=3, and HPPUMP is required only if KFM=4.

FIGURE III-34

CGSM INPUT - RCM NON-PROPULSION CER MULTIPLIERS
(NAMCNP NAMELIST)

VARIABLE	DEFINITION

AIRFRAME AND INTEGRATION TERMS

AFA1   RDT&E engineering rate per man-hour (see "a" in
        Equation (1) of Section 2.2.2) [$26/hr.]

AFB1   RDT&E engineering technology multiplier (see "b" in
        Equation (1) of Section 2.2.2) [1.0]

AFC1   RDT&E engineering complexity factor (see "c" in
        Equation (1) of Section 2.2.2) [1.0]

AFD1   RDT&E engineering inflation factor (see "d" in
        Equation (1) of Section 2.2.2) [1.0]

AFI1   RDT&E engineering miscellaneous cost (see "f" in
        Equation (1) of Section 2.2.2) [0.0]

AFA2   RDT&E development complexity factor (see "a" in
        Equation (2) of Section 2.2.2) [1.0]

AFB2   RDT&E development inflation factor (see "b" in
        Equation (2) of Section 2.2.2) [1.0]

AFG2   RDT&E development miscellaneous cost (see "g" in
        Equation (2) of Section 2.2.2) [0.0]

AFA3   RDT&E flight test complexity factor (see "a" in
        Equation (3) of Section 2.2.2) [1.0]

AFB3   RDT&E flight test cost inflation factor (see "b" in
        Equation (3) of Section 2.2.2) [1.0]

AFG3   RDT&E flight test miscellaneous cost (see "g" in
        Equation (3) of Section 2.2.2) [0.0]

AFA4   RDT&E tooling rate per man-hour (see "a" in
        Equation (4) of Section 2.2.2) [$19/hr.]

AFB4   RDT&E tooling technology factor (see "b" in
        Equation (4) of Section 2.2.2) [1.0]

AFC4   RDT&E tooling complexity factor (see "c" in
        Equation (4) of Section 2.2.2) [1.0]

AFD4   RDT&E tooling cost inflation factor (see "d" in
        Equation (4) of Section 2.2.2) [1.0]

FIGURE III-34 (Cont'd.)

VARIABLE	DEFINITION

AFJ4   RDT&E tooling miscellaneous cost (see "j" in Equation (4) of Section 2.2.2) [0.0]

AFA5   RDT&E manufacturing labor rate per man-hour (see "a" in Equation (5) of Section 2.2.2) [$12/hr.]

AFB5   RDT&E manufacturing labor complexity factor (see "b" in Equation (5) of Section 2.2.2) [1.0]

AFC5   RDT&E manufacturing labor cost inflation factor (see "c" in Equation (5) of Section 2.2.2) [1.0]

AFH5   RDT&E manufacturing labor miscellaneous cost (see "h" in Equation (5) of Section 2.2.2) [0.0]

AFA6   RDT&E manufacturing material complexity factor (see "a" in Equation (6) of Section 2.2.2) [1.0]

AFB6   RDT&E manufacturing material cost inflation factor (see "b" in Equation (6) of Section 2.2.2) [1.0]

AFG6   RDT&E manufacturing material miscellaneous cost (see "g" in Equation (6) of Section 2.2.2) [0.0]

AFA7   RDT&E quality assurance complexity factor (see "a" in Equation (7) of Section 2.2.2) [1.0]

AFC7   RDT&E quality assurance cost inflation factor (see "c" in Equation (7) of Section 2.2.2) [1.0]

AFD7   RDT&E quality assurance miscellaneous cost (see "d" in Equation (7) of Section 2.2.2) [0.0]

AFA8, AFB8, AFC8, AFD8, AFI8   Engineering production cost labor rate, technology factor, complexity factor, inflation multiplier, and miscellaneous cost terms (see "a", "b", "c", "d", and "i" in Equation (8) of Section 2.2.2) [$26/hr., 1.0, 1.0, 1.0, 0.0]

AFA9, AFB9, AFC9, AFD9, AFJ9   Production tooling cost labor rate, technology factor, complexity factor, inflation multiplier, and miscellaneous cost terms (see "a", "b", "c", "d", and "j" in Equation (9) of Section 2.2.2) [$19/hr., 1.0, 1.0, 1.0, 0.0]

AFA10, AFB10, AFC10, AFH10   Production manufacturing labor hourly rate, complexity factor, and miscellaneous cost terms (see "a", "b", "c", and "h" in Equation (10) of Section 2.2.2) [$12/hr., 1.0, 1.0, 1.0, 0.0]

FIGURE III-34 (Cont'd.)

VARIABLE	DEFINITION
AFA11, AFB11, AFG11	Production manufacturing material complexity factor, inflation factor, and miscellaneous cost (see "a", "b", and "g" in Equation (11) of Section 2.2.2) [1.0, 1.0 0.0]
AFA12, AFC12, AFD12	Production quality assurance complexity factor, inflation factor, and miscellaneous cost (see "a", "c", and "d" in Equation (12) of Section 2.2.2) [1.0, 1.0, 0.0]
AFA13, AFB13, AFC13	Total first unit production cost complexity factor, inflation factor, and miscellaneous cost (see "a", "b", and "c" in Equation (13) of Section 2.2.2) [1.0, 1.0, 0.0]
AFA14, AFB14, AFC14	Total RDT&E cost complexity factor, inflation factor, and miscellaneous cost (see "a", "b", and "c" in Equation (14) of Section 2.2.2) [1.0, 1.0, 0.0]

CONTROL TERMS

CA1	Controls RDT&E cost inflation factor (see "a" in Equation (1) of Section 2.4.2.2) [1.0]
CE1	Controls RDT&E CER complexity factor (see "e" in Equation (1) of Section 2.4.2.2) [1.0]
CF1	Controls RDT&E miscellaneous cost (see "f" in Equation (1) of Section 2.4.2.2 [0.0]
CA2	Controls production cost (with autopilot) inflation factor (see "a" in Equation (2) of Section 2.4.3.4) [1.0]
CE2	Controls production CER (with autopilot) complexity factor (see "e" in Equation (2) of Section 2.4.3.4) [1.0]
CF2	Controls production cost (with autopilot) miscellaneous cost (see "f" in Equation (2) of Section 2.4.3.4) [0.0]
CA3	Controls production CER (no autopilot) inflation factor (see "a" in Equation (3) of Section 2.4.3.5) [1.0]
CE3	Controls production cost (no autopilot) complexity factor (see "e" in Equation (3) of Section 2.4.3.5) [1.0]
CF3	Controls production cost (no autopilot) miscellaneous cost (see "f" in Equation (3) of Section 2.4.3.5) [0.0]

FIGURE III-34 (Cont'd.)

VARIANCE	DEFINITION

GUIDANCE TERMS

GA1 — Guidance RDT&E inflation factor (see "a" in Equation (1) of Section 2.4.2.1) [1.0]

GB1 — Guidance RDT&E complexity factor (see "b" in Equation (1) of Section 2.4.2.1) [1.0]

GF1 — Guidance RDT&E miscellaneous cost (see "g" in Equation (1) of Section 2.4.2.1) [0.0]

GA2 — Passive/semi-active production cost inflation factor (see "a" in Equation (2) of Section 2.4.3.1) [1.0]

GB2 — Passive/semi-active production complexity factor (see "b" in Equation (2) of Section 2.4.3.1) [1.0]

GK2 — Passive/semi-active miscellaneous production cost (see "k" in Equation (2) of Section 2.4.3.1) [0.0]

GA3 — Active production cost inflation factor (see "a" in Equation (3) of Section 2.4.3.2) [1.0]

GB3 — Active production cost complexity factor (see "b" in Equation (3) of Section 2.4.3.2) [1.0]

GQ3 — Active guidance miscellaneous production cost (see "q" in Equation (3) of Section 2.4.3.2) [0.0]

GA5 — IR production cost inflation factor (see "a" in Equation (5) of Section 2.4.3.3) [1.0]

GB5 — IR production cost complexity factor (see "b" in Equation (5) of Section 2.4.3.3) [1.0]

GH5 — IR miscellaneous production cost (see "h" in Equation (5) of Section 2.4.3.3) [0.0]

WARHEAD TERMS

WA1 — Warhead RDT&E inflation factor (see "a", Equation (1), Section 2.5.2, Vol. V) [1.0]

WE1 — Warhead RDT&E complexity factor (see "e", Equation (1), Section 2.5.2, Vol. V) [1.0]

WF1 — Warhead RDT&E miscellaneous cost (see "f" in Equation (1), Section 2.5.2, Vol. V) [0.0]

FIGURE III-34 (Cont'd.)

VARIABLE	DEFINITION
WA2	Warhead production cost inflation factor (see "a" in Equation (2) of Section 2.5.3) [1.0]
WD2	Warhead production cost complexity factor (see "d" in Equation (2) of Section 2.5.3) [1.0]
WE2	Warhead production cost miscellaneous cost (see "e" in Equation (2) of Section 2.5.3) [0.0]

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NOTE: Airframe and integration CERs are described in Volume V, Section 2.2. Controls CERs are defined in Section 2.4.2.2 (RDT&E), in Section 2.4.3.4 (with autopilot, and in Section 2.4.3.5 (no autopilot). Guidance CERs are defined in that volume in Sections 2.4.2.1 (RDT&E), 2.4.3.1 (passive/semi-active), 2.4.3.2 (active), and 2.4.3.3 (IR seeker). Warhead CERs are described in Section 2.5.

FIGURE III-35

CGSM INPUT - RCM NON-PROPULSION CER COEFFICIENTS
(NAMCCN NAMELIST)

VARIABLE	DEFINITION

AIRFRAME AND INTEGRATION TERMS

VARIABLE	DEFINITION
AFE1, AFF1, AFG1, AFH1	RDT&E engineering cost coefficients (see "e" through "h" in Equation (1) of Section 2.2.2)
AFC2, AFD2, AFE2, AFF2	RDT&E development cost coefficients (see "c" through "f" in Equation (2) of Section 2.2.2)
AFC3, AFD3, AFE3, AFF3	RDT&E flight test cost coefficients (see "c" through "f" in Equation (3) of Section 2.2.2)
AFE4, AFF4, AFG4, AFH4, AFI4	RDT&E tooling cost coefficients (see "e" through "i" in Equation (4) of Section 2.2.2)
AFD5, AFE5, AFF5, AFG5	RDT&E manufacturing labor cost coefficients (see "d" through "g" in Equation (5) of Section 2.2.2)
AFC6, AFD6, AFE6, AFF6	RDT&E manufacturing material cost coefficients (see "c" through "f" in Equation (6) of Section 2.2.2)
AFB7	RDT&E quality assurance miscellaneous cost (see "b" in Equation (7) of Section 2.2.2) [0.0]
AFE8, AFF8, AFG8, AFH8	Production engineering coefficients (see "e" through "h" in Equation (8) of Section 2.2.2)
AFE9, AFF9, AFG9, AFH9, AFI9	Production tooling coefficients (see "e" through "i" in Equation (9) of Section 2.2.2)
AFD10, AFE10, AFF10, AFG10	Production manufacturing labor coefficients (see "d" through "g" in Equation (10) of Section 2.2.2)
AFC11, AFD11, AFE11, AFF11	Production manufacturing material coefficients (see "c" through "f" in Equation (11) of Section 2.2.2)
AFB12	Production quality assurance coefficient (see "b" in Equation (12) of Section 2.2.2)

FIGURE III-35 (Cont'd.)

VARIABLE	DEFINITION

CONTROL TERMS

CB1, CC1, CD1	Controls RDT&E coefficients (see "b", "c", and "d" in Equation (1) of Section 2.4.2.2)
CB2, CC2, CD2	Controls production (with autopilot) coefficients (see "b", "c", and "d" in Equation (3) of Section 2.4.3.4)
CB3, CC3, CD3	Controls production (no autopilot) coefficients (see "b", "c", and "d" in Equation (3) of Section 2.4.3.5)

GUIDANCE TERMS

GC1, GD1, GE1	Guidance RDT&E coefficients (see "c", "d", and "f" in Equation (1) of Section 2.4.2.1)
GC2, GD2, GE2, GF2, GG2, GH2, GI2, GJ2	Passive/semi-active production cost coefficients (see "c" through "j" in Equation (2) of Section 2.4.3.1)
GC3, GD3, GE3, GF3, GG3, GH3, GI3, GJ3, GK3, GL3, GM3, GN3, GP3	Active production cost coefficients (see "c" through "p" in Equation (3) of Section 2.4.3.2)
GC5, GD5, GE5, GF5, GG5	IR production coefficients (see "c" through "g" in Equation (5) of Section 2.4.3.3)

WARHEAD TERMS

WB1, WC1, WD1	Warhead RDT&E coefficients (see "b", "c", and "d" in Equation (1) of Section 2.5.2)
WB2, WC2	Warhead production coefficients (see "b" and "c" in Equation (2) of Section 2.5.3)

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NOTE: Airframe and integration CERs are described in Section 2.2 of Vol. V. Controls CERs are defined in Section 2.4.2.2 (RDT&E) in Section 2.4.3.4 (with autopilot), and in Section 2.4.3.5 (no autopilot). Guidance CERs are defined in Section 2.4.2.1 (RDT&E), in 2.4.3.1 (passive/semi-active), in 2.4.3.2 (active), and in 2.4.3.3 (IR seeker). Warhead CERs are described in Section 2.5.

FIGURE III-36

CGSM INPUT - RCM PROPULSION CER MULTIPLIERS

(NAMCPS NAMELIST)

VARIABLE	DEFINITION

LIQUID ROCKET SUSTAINER TERMS

PLA1 — Thrust chamber labor rate (see "a" in Equation (1) of Section 2.3.2.1) [$10/hr.]

PLA3 — Thrust chamber complexity factor (see "a" in Equation (3) of Section 2.3.2.1) [1.0]

PLB3 — Thrust chamber miscellaneous cost (see "b" in Equation (3) of Section 2.3.2.1) [0.0]

PLA4 — Turbopump labor rate (see "a" in Equation (4) of Section 2.3.2.2) [$10/hr.]

PLA6 — Gas generator and start cartridge labor rate (see "a" in Equation (6) of Section 2.3.2.2) [$10/hr.]

PLA8 — Turbopump complexity factor (see "a" in Equation (8) of Section 2.3.2.2) [1.0]

PLB8 — Turbopump miscellaneous cost (see "b" in Equation (8) of Section 2.3.2.2) [0.0]

PLA9 — Engine miscellaneous hardware labor cost complexity factor (see "a" in Equation (9) of Section 2.3.2.3) [1.0]

PLA11 — Engine total miscellaneous hardware cost complexity factor (see "a" in Equation (11) of Section 2.3.2.3) [1.0]

PLB11 — Miscellaneous cost term for engine total miscellaneous hardware (see "b" in Equation (11) of Section 2.3.2.3) [0.0]

PLA13 — Pressurization system cost complexity factor (see "a" in Equation (13) of Section 2.3.2.4) [1.0]

PLB13 — Pressurization system regulator cost (see "b" in Equation (13) of Section 2.3.2.4) [0.275]

PLC13 — Pressurization system miscellaneous valves cost (see "c" in Equation (13) of Section 2.3.2.4) [0.275]

PLD13 — Pressurization system miscellaneous cost term (see "d" in Equation (13) of Section 2.3.2.4) [0.0]

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION
PLA14	Tankage complexity factor (see "a" in Equation (14) of Section 2.3.2.5) [1.0]
PLB14	Materials cost factor used to adjust tankage cost (internal value dependent on METAL used if input as zero) (see "b" in Equation (14) of Section 2.3.2.4) [0.0]
PLD14	Miscellaneous tankage cost (see "d" in Equation (14) of Section 2.3.2.5) [0.0]
PLA15	Fuel/oxidizer cost complexity factor (see "a" in Equation (15) of Section 2.3.2.6) [1.0]
PLB15	Oxidizer cost per pound (see "b" in Equation (15) of Section 2.3.2.6) [0.11/lb.]
PLE15	Fuel cost per pound (see "e" in Equation (15) of Section 2.3.2.6) [$1.18/lb.]
PLF15	Miscellaneous fuel/oxidizer cost (see "f" in Equation (15) of Section 2.3.2.6) [0.0]
PLA16	Propellant loading cost complexity factor (see "a" in Equation (16) of Section 2.3.2.6) [1.0]
PLE16	Propellant loading miscellaneous cost (see "e" in Equation (16) of Section 2.3.2.6) [0.0]
PLA17	Safe and arm system cost (see Equation (17) of Section 2.3.2.7) [0.1925]
PLA18, PLB18, PLC18	Total first unit cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (18) of Section 2.3.2.8) [1.0, 1.0, 0.0]
PLA19, PLB19, PLC19	RDT&E cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (19) of Section 2.3.2.9) [1.0, 1.0, 0.0]
PLPC	Liquid rocket contractor profit margin [0.1]

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION

EXTERNAL BOOSTER TERMS

PEA3 — Motor case cost complexity factor (see "a" in Equation (3) of Section 2.3.6.1) [1.0]

PEB3 — Motor case miscellaneous cost (see "b" in Equation (3) of Section 2.3.6.1) [0.0]

PEA4, PEE4 — Motor internal insulation complexity factor and miscellaneous cost (see "a" and "e" in Equation (4) of Section 2.3.6.1) [1.0, 0.0]

PEA5, PEF5 — Nozzle cost complexity factor and miscellaneous cost (see "a" and "f" in Equation (5) of Section 2.3.6.2) [1.0, 0.0]

PEA6, PEE6 — Propellant cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (6) of Section 2.3.6.3) [1.0, 0.0]

PEB6 — Propellant cost per pound (see "b" in Equation (6) of Section 2.3.6.3) [$1.00/lb.]

PEA7, PEE7 — Propellant loading cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (7) of Section 2.3.6.3) [1.0, 0.0]

PEA8 — Igniter cost (see Section 2.3.6.4) [0.3861]

PEA9 — Safe and arm system cost (see Section 2.3.6.4) [0.19305]

PEA10, PEB10, PEC10 — Total first unit cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (10) of Section 2.3.6.5) [1.0, 1.0, 0.0]

PEA11, PEB11, PEE11 — RDT&E inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "e" in Equation (11) of Section 2.3.6.6) [1.0, 1.0, 0.0]

CFM — Materials cost factor used to adjust case labor cost (internal value dependent on CASEM used if input as zero) [0.0]

PFM — Materials cost factor used to adjust case materials cost (internal value dependent on CASEM used if input as zero) [0.0]

PEBC — External booster contractor profit margin [0.1]

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION

SOLID ROCKET SUSTAINER TERMS

PSA3, PSB3 Motor case complexity factor and miscellaneous cost (see "a" and "b" in Equation (3) of Section 2.3.1.1 [1.0, 0.0]

PSA4, PSE4 Case insulation complexity factor and miscellaneous cost (see "a" and "e" in Equation (4) of Section 2.3.1.1) [1.0, 0.0]

PSA5, PSF5 Nozzle cost complexity factor and miscellaneous cost (see "a" and "f" in Equation (5) of Section 2.3.1.2) [1.0, 0.0]

PSA6, PSG6 Propellant cost complexity factor and miscellaneous cost (see "a" and "g" in Equation (6) of Section 2.3.1.3) [1.0, 0.0]

PSF6 Propellant cost per pound (see "f" in Equation (6) of Section 2.3.1.3) [$1.00/lb.]

PSA7, PSF7 Propellant loading cost complexity factor and miscellaneous cost (see "a" and "f" in Equation (7) of Section 2.3.1.3) [1.0, 0.0]

PSA8 Safe and arm cost (see Equation (8) in Section 2.3.1.4) [0.19305]

PSA9 Igniter cost (see Equation (9) in Section 2.3.1.4) [0.3861]

PSA10, PSB10, PSC10 Total production cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (10) of Section 2.3.1.5) [1.0, 1.0, 0.0]

PSA11, PSB11, PSE11 RDT&E inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "e" in Equation (11) of Section 2.3.1.6) [1.0, 1.0, 0.0]

TURBOJET SUSTAINER TERMS

PTA1, PTD1 Engine complexity factor and miscellaneous cost (see "a" and "d" in Equation (1) of Section 2.3.3.1) [1.0, 0.0]

PTA4, PTB4 Total tank cost complexity factor and miscellaneous cost (see "a" and "b" in Equation (4) of Section 2.3.3.2) [1.0, 0.0]

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION
PTA5, PTE5	Fuel cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (5) of Section 2.3.3.3) $[1.0, 0.0]$
PTB5	Fuel cost per pound (see "b" in Equation (5) of Section 2.3.3.3) $[0.1]$
PTA6, PTE6	Fuel loading cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (6) of Section 2.3.3.3) $[1.0, 0.0]$
PTA7, PTB7, PTC7	Total production first unit cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (7) of Section 2.3.3.4) $[1.0, 1.0, 0.0]$
PTA10, PTB10, PTC10	RDT&E inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (10) of Section 2.3.3.5) $[1.0, 1.0, 0.0]$
PTJC	Turbojet contractor profit margin $[0.1]$
CFT	Materials factor used to compute tank labor cost (internal value dependent on MATTK used if input as zero) (see Equation (2) of Section 2.3.3.2) $[0.0]$
PFT	Materials factor used to compute tank material cost (internal value dependent on MATTK used if input as zero) (see Equation (3) of Section 2.3.3.2) $[0.0]$

INTEGRAL RAMJET TERMS

VARIABLE	DEFINITION
PRIA1	Tank labor cost complexity factor (see "a" in Equation (1) of Section 2.3.4.1) $[1.0]$
PRIA2	Tank material cost complexity factor (see "a" in Equation (2) of Section 2.3.4.1) $[1.0]$
PRIA3, PRIB3	Total tank cost complexity factor and miscellaneous cost (see "a" and "b" in Equation (3) of Section 2.3.4.1) $[1.0, 0.0]$
PRIA4, PRIE4	Tank external insulation cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (4) of Section 2.3.4.1) $[1.0, 0.0]$
PRIA5	Nitrogen gas bottle complexity factor (see "a" in Equation (5) of Section 2.3.4.1) $[1.0]$

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION
PRIA6	Regulator cost (see Equation (6) in Section 2.3.4.1) [0.275]
PRIA7	Miscellaneous valves cost (see Equation (7) of Section 2.3.4.1) [0.275]
PRIA8, PRIB8	Nitrogen gas pressurization system total cost complexity factor and miscellaneous cost (see "a" and "b" in Equation (8) of Section 2.3.4.1) [1.0, 0.0]
PRIA9, PRIG9	Solid gas pressurization system total cost complexity factor and miscellaneous cost (see "a" and "g" in Equation (9) of Section 2.3.4.2) [1.0, 0.0]
PRIA10	Monopropellant gas pressurization system cost (see Equation (10) of Section 2.3.4.2) [5.1975]
PRIA11, PRIG11	Ram-air turbine pressurization system cost complexity factor and miscellaneous cost (see "a" and "g" in Equation (11) of Section 2.3.4.2) [1.0, 0.0]
PRIA12, PRJE12	Fuel cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (12) of Section 2.3.4.3) [1.0, 0.0]
PRIB12	Fuel cost per pound (see "b" in Equation (12) of Section 2.3.4.3) [$1.00/lb]
PRIA13, PRIE13	Fuel loading cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (13) of Section 2.3.4.3) [1.0, 0.0]
PRIA14, PRIE14	Combustor case labor cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (14) of Section 2.3.4.4) [1.0, 0.0]
PRIA15, PRIE15	Combustor case material cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (15) of Section 2.3.4.4) [1.0, 0.0]
PRIA16, PRIE16	Case insulation cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (16) of Section 2.3.4.4) [1.0, 0.0]
PRIA17, PRIF17	Nozzle cost complexity factor and miscellaneous cost (see "a" and "f" in Equation (17) of Section 2.3.4.4) [1.0, 0.0]
PRIA18, PRIE18	Booster propellant cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (18) of Section 2.3.4.4) [1.0, 0.0]

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FIGURE III-39 (Continued)

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION
PRIB18	Booster propellant cost per pound (see "b" in Equation (18) of Section 2.3.4.4) [$1.00/lb.]
PRIA19, PRIE19	Booster propellant loading cost complexity factor and miscellaneous cost (see "a" and "e" in Equation (19) of Section 2.3.4.4) [1.0, 0.0]
PRIA20	Booster igniter cost (see Equation (20) in Section 2.3.4.4) [0.3861]
PRIA21	Booster safe and arm cost (see Equation (21) of Section 2.3.4.4) [0.19305]
PRIA22, PRIB22	Total booster/combustor cost complexity factor and miscellaneous cost (see "a" and "b" in Equation (22) of Section 2.3.4.4) [1.0, 0.0]
PRIA23, PRIB23, PRIC23	Total ramjet first unit production cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (23) of Section 2.3.4.4) [1.0, 1.0, 0.0]
PRIA26, PRIB26, PRIC26	RDT&E cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (26) of Section 2.3.4.5) [1.0, 1.0, 0.0]
CFCASE	Materials factor used in computing combustor cost (internal value dependent on CASEM used if input as zero) [0.0]
PFCASE	Materials factor used in computing combustor cost (internal value dependent on CASEM used if input as zero) [0.0]
CFT	Materials factor used in computing fuel tank labor cost (internal value dependent on MATTK used if input as zero) [0.0]
PFT	Materials factor used in computing fuel tank material cost (internal value dependent on MATTK used if input as zero) [0.0]
PRJC	Ramjet contractor profit margin [0.1]

FIGURE III-36 (Cont'd.)

VARIABLE   DEFINITION

NON-INTEGRAL RAMJET TERMS

PRNA1   Tank labor cost complexity factor (see "a" in Equation
                     (1) of Section 2.3.4.1) [1.0]

PRNA2   Tank material cost complexity factor (see "a" in
                     Equation (2) of Section 2.3.4.1) [1.0]

PRNA3, PRNB3   Total tank cost complexity factor and miscellaneous cost
                     (see "a" and "b" in Equation (3) of Section 2.3.4.1)
                     [1.0, 0.0]

PRNA4, PRNE4   Tank external insulation cost complexity factor and
                     miscellaneous cost (see "a" and "e" in Equation (4) of
                     Section 2.3.4.1) [1.0, 0.0]

PRNA5   Nitrogen gas bottle complexity factor (see "a" in
                     Equation (5) of Section 2.3.4.1) [1.0]

PRNA6   Regulator cost (see Equation (6) in Section 2.3.4.1)
                     [0.275]

PRNA7   Miscellaneous valves cost (see Equation (7) in Section
                     2.3.4.1) [0.275]

PRNA8, PRNB8   Nitrogen gas pressurization system total cost com-
                     plexity factor and miscellaneous cost (see "a" and "b"
                     in Equation (8) of Section 2.3.4.1) [1.0, 0.0]

PRNA9, PRNG9   Solid gas pressurization system total cost complexity
                     factor and miscellaneous cost (see "a" and "g" in
                     Equation (9) of Section 2.3.4.2) [1.0, 0.0]

PRNA10   Monopropellant gas pressurization system cost (see
                     Equation (10) of Section 2.3.4.2) [5.1975]

PRNA11, PRNG11   Ram-air turbine pressurization system cost complexity
                     factor and miscellaneous cost (see "a" and "g" in
                     Equation (11) of Section 2.3.4.2) [1.0, 0.0]

PRNA12, PRNE12   Fuel cost complexity factor and miscellaneous cost (see
                     "a" and "e" in Equation (12) of Section 2.3.4.3) [1.0, 0.0]

PRNB12   Fuel cost per pound (see "b" in Equation (12) of Section
                     2.3.4.3) [$1.00/lb.]

PRNA13, PRNE13   Fuel loading cost complexity factor and miscellaneous
                     cost (see "a" and "e" in Equation (13) of Section 2.3.4.3)
                     [1.0, 0.0]

FIGURE III-36 (Cont'd.)

VARIABLE	DEFINITION
PRNA14	Combustor case labor cost complexity factor (see "a" in Equation (14) of Section 2.3.5.1) [1.0]
PRNA15	Combustor case material cost complexity factor (see "a" in Equation (15) of Section 2.3.5.1) [1.0]
PRNA16	Case insulation cost complexity factor (see "a" in Equation (16) of Section 2.3.5.1) [1.0]
PRNA17	Nozzle cost complexity factor (see "a" in Equation (17) of Section 2.3.5.2) [1.0]
PRNA18, PRNB18	Total combustor cost complexity factor and miscellaneous cost (see "a" and "b" in Equation (18) of Section 2.3.5.2) [1.0, 0.0]
PRNA19, PRNB19, PRNC19	Total ramjet first unit production cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (19) of Section 2.3.5.2) [1.0, 1.0, 0.0]
PRNA22, PRNB22, PRNC22	RDT&E cost inflation factor, complexity factor, and miscellaneous cost (see "a", "b", and "c" in Equation (22) of Section 2.3.5.2) [1.0, 1.0, 0.0]
CFC	Materials factor used to compute combustor labor cost (internal value dependent on CASEM used if input as zero) [0.0]
PFC	Materials factor used to compute combustor material cost (internal value dependent on CASEM used if input as zero) [0.0]
CFT	Materials factor used to compute fuel tank labor cost (internal value dependent on MATTK used if input as zero) [0.0]
PFT	Materials factor used to compute fuel tank material cost (internal value dependent on MATTK used if input as zero) [0.0]
PRJC	Ramjet contractor profit margin [0.1]

FIGURE III-37

CGSM INPUT - RCM PROPULSION CER COEFFICIENTS
(NAMCCP NAMELIST)

VARIABLE	DEFINITION

LIQUID ROCKET SUSTAINER TERMS

PLB1, PLC1	Thrust chamber labor coefficients (see "b" and "c" in Equation (1) of Section 2.3.2.1)
PLA2, PLB2	Thrust chamber materials coefficients (see "a" and "b" in Equation (2) of Section 2.3.2.1)
PLB4, PLC4	Turbopump labor coefficients (see "b" and "c" in Equation (4) of Section 2.3.2.2)
PLA5, PLB5	Turbopump materials coefficients (see "a" and "b" in Equation (5) of Section 2.3.2.2)
PLB6, PLC6	Gas Generator and start cartridge labor coefficients (see "b" and "c" in Equation (6) of Section 2.3.2.2)
PLA7, PLB7	Gas generator and start cartridge material coefficients (see "a" and "b" in Equation (7) of Section 2.3.2.2)
PLB9, PLC9	Miscellaneous hardware labor coefficients (see "b" and "c" in Equation (9) of Section 2.3.2.3)
PLA10, PLB10	Miscellaneous hardware materials coefficients (see "a" and "b" in Equation (10) of Section 2.3.2.3)
PLA12, PLB12	Nitrogen storage bottle coefficients (see "a" and "b" in Equation (12) of Section 2.3.2.4)
PLB14, PLC14	Tankage cost coefficients (see "b" and "c" in Equation (14) of Section 2.3.2.4)
PLC15, PLD15	Fuel/oxidizer cost coefficients (see "c" and "d" in Equation (15) of Section 2.3.2.5)
PLB16, PLC16, PLD16	Propellant loading cost coefficients (see "b", "c", and "d" in Equation (16) of Section 2.3.2.6)
PLD19, PLE19	RDT&E cost coefficients (see "d" and "e" in Equation (19) of Section 2.3.2.9)

FIGURE III-37 (Cont'd.)

VARIABLE	DEFINITION

EXTERNAL BOOSTER TERMS

PEA1, PEB1, PEC1	Motor case labor cost coefficients (see "a", "b", and "c" in Equation (1) of Section 2.3.6.1)
PEA2, PEB2, PEC2	Case material cost coefficients (see "a", "b", and "c" in Equation (2) of Section 2.3.6.1)
PEB4, PEC4, PED4	Motor total cost coefficients (see "b", "c", and "d" in Equation (4) of Section 2.3.6.1)
PEB5, PEC5, PED5, PEE5	Nozzle coefficients (see "b", "c", "d", and "e" in Equation (5) of Section 2.3.6.2)
PEC6, PED6	Propellant cost coefficients (see "c" and "d" in Equation (6) of Section 2.3.6.3)
PEB7, PEC7, PED7	Propellant loading cost coefficients (see "b", "c", and "d" in Equation (7) of Section 2.3.6.3)
PEC11, PED11	RDT&E cost coefficients (see "c" and "d" in Equation (11) of Section 2.3.6.6)

SOLID ROCKET SUSTAINER TERMS

PSA1, PSB1, PSC1	Motor case labor cost coefficients (see "a", "b", and "c" in Equation (1) of Section 2.3.1.1)
PSA2, PSB2, PSC2	Motor case material cost coefficients (see "a", "b", and "c" in Equation (2) of Section 2.3.1.1)
PSB4, PSC4, PSD4	Case insulation cost coefficients (see "b", "c", and "d" in Equation (4) of Section 2.3.1.1)
PSB5, PSC5, PSD5, PSE5	Nozzle cost coefficients (see "b", "c", "d", and "e" in Equation (5) of Section 2.3.1.2)
PSB6, PSC6, PSD6, PSE6	Propellant cost coefficients (see "b", "c", "d" and "e" in Equation (6) of Section 2.3.1.3)
PSB7, PSC7, PSD7, PSE7	Propellant loading cost coefficients (see "b", "c", "d", and "e" in Equation (7) of Section 2.3.1.3)
PSC11, PSD11	RDT&E cost coefficients (see "c" and "d" in Equation (11) of Section 2.3.1.6)

FIGURE III-37 (Cont'd.)

VARIABLE	DEFINITION

TURBOJET SUSTAINER TERMS

PTB1, PTC1 — Engine cost coefficients (see "b" and "c" in Equation (1) of Section 2.3.3.1)(PTB1 is set internally based on turbine inlet temperature if input as zero)

PTA2, PTB2 — Tankage labor cost coefficients (see "a" and "b" in Equation (2) of Section 2.3.3.2)

PTA3, PTB3 — Tankage material cost coefficients (see "a" and "b" in Equation (3) of Section 2.3.3.2)

PTC5, PTD5 — Fuel cost coefficients (see "c" and "d" in Equation (5) of Section 2.3.3.3)

PTB6, PTC6, PTD6 — Fuel loading cost coefficients (see "b", "c", and "d" in Equation (6) of Section 2.3.3.3)

PTD10, PTE10 — RDT&E cost coefficients (see "d" and "e" in Equation (10) of Section 2.3.3.5)

INTEGRAL RAMJET TERMS

PRIB1, PRIC1 — Tank labor cost coefficients (see "b" and "c" in Equation (1) of Section 2.3.4.1)

PRIB2, PRIC2 — Tank material cost coefficients (see "b" and "c" in Equation (2) of Section 2.3.4.1)

PRIB4, PRIC4, PRID4 — Tank external insulation cost coefficients (see "b", "c", and "d" in Equation (4) of Section 2.3.4.1)

PRIB5, PRIC5 — Nitrogen gas bottle cost coefficients (see "b" and "c" in Equation (5) of Section 2.3.4.1)

PRIB9, PRIC9, PRID9, PRIE9, PRIF9 — Solid gas pressurization system cost coefficients (see "b", "c", "d", "e", and "f" in Equation (9) of Section 2.3.4.2)

PRIB11, PRIC11, PRID11, PRIE11, PRIF11 — Ram-air turbine pressurization system cost coefficients (see "b" through "f" in Equation (11) of Section 2.3.4.2)

PRIC12, PRID12 — Fuel cost coefficients (see "c" and "d" in Equation (12) of Section 2.3.4.3)

PRIB13, PRIC13, PRID13 — Fuel loading cost coefficients (see "b", "c", and "d" in Equation (13) of Section 2.3.4.3)

FIGURE III-37 (Cont'd.)

VARIABLE	DEFINITION
PRIB14, PRIC14, PRID14	Combustor case labor cost coefficients (see "b", "c", and "d" in Equation (14) of Section 2.3.4.4)
PRIB15, PRIC15, PRID15	Combustor case material cost coefficients (see "b", "c", and "d" in Equation (15) of Section 2.3.4.4)
PRIB16, PRIC16, PRID16	Combustor case insulation cost coefficients (see "b", "c", and "d" in Equation (16) of Section 2.3.4.4)
PRIB17, PRIC17, PRID17, PRIE17	Nozzle cost coefficients (see "b", "c", "d", and "e" in Equation (17) of Section 2.3.4.4)
PRIC18, PRID18	Booster propellant cost coefficients (see "c" and "d" in Equation (18) of Section 2.3.4.4)
PRIB19, PRIC19, PRID19	Booster propellant loading cost coefficients (see "b", "c", and "d" in Equation (19) of Section 2.3.4.4)
PRID26	RDT&E cost coefficient (see "d" in Equation (26) of Section 2.3.4.5)

NON-INTEGRAL RAMJET TERMS

VARIABLE	DEFINITION
PRNB1, PRNC1	Tank labor cost coefficients (see "b" and "c" in Equation (1) of Section 2.3.4.1)
PRNB2, PRNC2	Tank material cost coefficients (see "b" and "c" in Equation (2) of Section 2.3.4.1)
PRNB4, PRNC4, PRND4	Tank external insulation cost coefficients (see "b", "c", and "d" in Equation (4) of Section 2.3.4.1)
PRNB5, PRNC5	Nitrogen gas bottle cost coefficients (see "b" and "c" in Equation (5) of Section 2.3.4.1)
PRNB9, PRNC9. PRND9, PRNE9, PRNF9	Solid gas pressurization system cost coefficients (see "b", "c", "d", "e", and "f" in Equation (9) of Section 2.3.4.2)
PRNB11, PRNC11, PRND11, PRNE11, PRNF11	Ram-air turbine pressurization system cost coefficients (see "b" through "f" in Equation (11) of Section 2.3.4.2)
PRNC12, PRND12	Fuel cost coefficients (see "c" and "d" in Equation (12) of Section 2.3.4.3)
PRNB13, PRNC13, PRND13	Fuel loading cost coefficients (see "b", "c", and "d" in Equation (13) of Section 2.3.4.3)

FIGURE III-37 (Cont'd.)

VARIABLE	DEFINITION
PRNB14, PRNC14, PRND14	Combustor case labor cost coefficients (see "b", "c", and "d" in Equation (14) of Section 2.3.5.1)
PRNB15, PRNC15, PRND15	Combustor case material cost coefficients (see "b", "c", and "d" in Equation (15) of Section 2.3.5.1)
PRNB16, PRNC16, PRND16	Combustor case insulation cost coefficients (see "b", "c", and "d" in Equation (16) of Section 2.3.5.1)
PRNB17, PRNC17, PRND17, PRNE17	Nozzle cost coefficients (see "b", "c", "d", and "e" in Equation (17) of Section 2.3.5.2)
PRND22	RDT&E cost coefficient (see "d" in Equation (22) of Section 2.3.5.2)

5.   BLOCK DATA INPUT

Most prestored values for NAMELIST list items are set through
BLOCK DATA modules. Those modules and their settings are provided
for convenience only, and will not normally change. However, there is
a second category of BLOCK DATA in the CGSM which performs the function
of true input. Liquid fuel performance characteristics and solid propellant
performance characteristics are prestored through BLOCK DATA and can-
not be altered through the conventional CGSM table/list input options. Any
change to those performance data must be effected by coding and compiling
a revised set of BLOCK DATA modules. The advantage of using BLOCK
DATA for those data lies in the significant reduction in computer field
length requirements.

5.1   Liquid Fuel Input

Liquid sustainer fuel data are stored in two forms. The first
requirement is for theoretical specific impulse (ISP) as a function of
expansion ratio (ER), mixture ratio (MR), and chamber pressure (PC).
Also required is expansion ratio as a function of ISP, MR and PC. Both
of those data requirements are filled in the CGSM through BLØCK DATA
storage. A N_2O_4/UDMH (oxidizer/fuel) propellant type is stored, in
the form shown in Figures III-38 and III-39.

The liquid fuel specific impulse table is stored in a CØMMON
block defined by

CØMMØN RØCL/TAISP(631).

The TIASP array is shown in Figure III-38 to consist of the following
components:

TAISP(1)−(5) ≡ PC(1)−(5),

TAISP(6)−(11) ≡ MR(1)−(6),

TAISP(12)−(31) ≡ ER(1)−(20),

and   TAISP(32)−(631) ≡ ISP(1,1,1)−(20,6,5)

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FIGURE III-38
Liquid Rocket Fuel Deck - Specific Impulse Table

```
DATA NPCP,NMRP,NEXR/5,6,20/

      #PC        #MR        #ER


  ISP(1,1,1)

   DATA TAISP /  20.,   100.,   300.,   500.,   2000.,    }   PC
 1 2.0,  2.2,  2.4,  2.6,  2.8,  3.0,                      }     MR
 2 4.0,  6.0,  8.0,10.0,12.0,14.0,16.0,18.0,20.0,25.0,30.0,35.0, }  ER
 340.0,45.0,50.0,60.0,70.0,80.0,90.0,100.0,
 4 279.9,   291.5,   298.7,   303.7,   307.5,   310.5,   313.0,
 5 315.0,   316.9,   320.5,   323.2,   325.4,   327.3,   328.8,
 6 330.2,   332.4,   334.2,   335.6,   336.9,   338.0,
 7 280.0,   292.3,   300.0,   305.3,   309.4,   312.6,   315.3,
 8 317.6,   319.5,   323.4,   326.3,   328.7,   330.7,   332.3,
 9 333.8,   336.2,   338.1,   339.7,   341.0,   342.2,
 A 278.6,   291.5,   299.6,   305.3,   309.7,   313.2,   316.1,
 B 318.5,   320.7,   324.8,   328.0,   330.5,   332.7,   334.5,
 C 336.0,   338.6,   340.6,   342.4,   343.8,   345.1,
 D 276.2,   289.4,   297.8,   303.9,   308.5,   312.2,   315.3,
 E 317.9,   320.2,   324.7,   328.2,   331.0,   333.3,   335.2,
 F 336.9,   339.7,   341.9,   343.8,   345.4,   346.7,


        ISP(1,5,1)                              ISP(20,4,1)


 1 273.4,   286.6,   295.1,   301.3,   306.0,   309.9,   313.1,
 2 315.8,   318.3,   323.1,   326.9,   329.9,   332.4,   334.5,
 3 336.4,   339.4,   341.8,   343.9,   345.6,   347.1,
 4 270.5,   283.6,   292.1,   298.2,   303.0,   306.8,   310.1,
 5 312.8,   315.2,   320.2,   324.1,   327.2,   329.8,   332.1,
 6 334.1,   337.4,   340.0,   342.3,   344.2,   345.8,

                        ISP(20,6,1)
```

FIGURE III-38 (Continued)

ISP(1, 1, 2)

```
1 282.1,   293.4,   300.3,   305.2,   308.9,   311.8,   314.3,
2 316.3,   318.1,   321.6,   324.3,   326.4,   328.2,   329.7,
3 331.0,   333.2,   335.0,   336.4,   337.7,   338.7,
4 283.1,   295.0,   302.4,   307.6,   311.5,   314.7,   317.2,
5 319.4,   321.3,   325.0,   327.9,   330.2,   332.1,   333.7,
6 335.1,   337.4,   339.3,   340.8,   342.1,   343.3,
7 282.5,   295.1,   302.9,   308.4,   312.6,   316.0,   318.7,
8 321.0,   323.0,   327.1,   330.1,   332.6,   334.6,   336.4,
9 337.8,   340.3,   342.3,   344.0,   345.4,   346.6,
A 280.7,   293.7,   302.0,   307.8,   312.3,   315.8,   318.8,
B 321.3,   323.5,   327.7,   331.0,   333.7,   335.9,   337.7,
C 339.3,   342.0,   344.1,   345.9,   347.4,   348.7,
D 278.0,   291.2,   299.7,   305.8,   310.4,   314.2,   317.4,
E 320.0,   322.3,   327.0,   330.5,   333.4,   335.8,   337.8,
F 339.5,   342.4,   344.7,   346.6,   348.2,   349.7,
G 275.1,   288.2,   296.7,   302.8,   307.5,   311.3,   314.5,
H 317.3,   319.6,   324.5,   328.3,   331.3,   333.9,   336.1,
I 338.0,   341.1,   343.6,   345.7,   347.5,   349.1,
```

ISP(20, 6, 2)

ISP(1, 1, 3)

```
1 283.1,   294.3,   301.1,   305.9,   309.6,   312.5,   314.9,
2 316.9,   318.6,   322.1,   324.8,   326.9,   328.7,   330.2,
3 331.5,   333.6,   335.4,   336.8,   338.0,   339.1,
4 284.7,   296.4,   303.7,   308.8,   312.6,   315.7,   318.2,
5 320.2,   322.2,   325.9,   328.7,   331.0,   332.8,   334.4,
6 335.8,   338.1,   339.9,   341.4,   342.7,   343.8,
7 284.8,   297.1,   304.7,   310.1,   314.2,   317.5,   320.2,
8 322.4,   324.4,   328.3,   331.3,   333.7,   335.7,   337.4,
9 338.8,   341.3,   343.2,   344.8,   346.2,   347.4,
A 283.4,   296.3,   304.3,   310.1,   314.4,   317.9,   320.7,
B 323.1,   325.3,   329.4,   332.6,   335.2,   337.3,   339.1,
C 340.7,   343.3,   345.3,   347.1,   348.5,   349.8,
D 281.0,   294.2,   302.5,   308.5,   313.1,   316.8,   319.8,
E 322.4,   324.7,   329.2,   332.6,   335.4,   337.7,   339.6,
F 341.3,   344.1,   346.3,   348.2,   349.7,   351.1,
G 278.1,   291.2,   299.6,   305.7,   310.4,   314.1,   317.3,
H 320.0,   322.3,   327.1,   330.8,   333.8,   336.3,   338.4,
I 340.2,   343.3,   345.7,   347.7,   349.5,   351.0,
```

ISP(20, 6, 3)

FIGURE III-38 (Continued)

ISP(1, 1, 4)

```
1 283.5,   294.6,   301.4,   306.2,   309.9,   312.7,   315.1,
2 317.1,   318.8,   322.3,   325.0,   327.1,   328.9,   330.3,
3 331.6,   333.8,   335.5,   336.9,   338.2,   339.2,
4 285.4,   297.0,   304.2,   309.2,   313.0,   316.1,   318.6,
5 320.5,   322.5,   326.2,   329.0,   331.3,   333.1,   334.7,
6 336.1,   338.3,   340.1,   341.6,   342.9,   344.0,
7 285.7,   297.9,   305.5,   310.8,   314.8,   318.1,   320.7,
8 323.0,   324.9,   328.8,   331.8,   334.1,   336.1,   337.8,
9 339.2,   341.6,   343.6,   345.2,   346.5,   347.7,
A 284.6,   297.4,   305.3,   311.0,   315.3,   318.7,   321.5,
B 323.9,   325.9,   330.1,   333.3,   335.8,   337.9,   339.7,
C 341.2,   343.8,   345.8,   347.5,   349.0,   350.2,
D 282.3,   295.4,   303.7,   309.7,   314.2,   317.9,   320.9,
E 323.5,   325.7,   330.1,   333.5,   336.2,   338.4,   340.4,
F 342.0,   344.8,   347.0,   348.8,   350.3,   351.7,
G 279.4,   292.5,   300.9,   306.9,   311.6,   315.4,   318.5,
H 321.2,   323.6,   328.3,   331.9,   334.9,   337.3,   339.4,
I 341.2,   344.2,   346.6,   348.6,   350.3,   351.7,
```
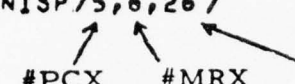
ISP(20, 6, 4)

ISP(1, 1, 5)

```
1 284.3,   295.3,   302.0,   306.8,   310.3,   313.2,   315.5,
2 317.5,   319.3,   322.7,   325.3,   327.4,   329.2,   330.7,
3 332.0,   334.1,   335.8,   337.2,   338.4,   339.5,
4 286.7,   298.1,   305.2,   310.1,   313.9,   316.9,   319.3,
5 321.6,   323.3,   326.9,   329.7,   331.9,   333.7,   335.3,
6 336.6,   338.8,   340.6,   342.1,   343.4,   344.5,
7 287.7,   299.7,   307.0,   312.2,   316.2,   319.4,   322.0,
8 324.1,   326.0,   329.9,   332.8,   335.1,   337.0,   338.7,
9 340.1,   342.4,   344.3,   345.9,   347.2,   348.4,
A 287.3,   299.8,   307.6,   313.1,   317.2,   320.6,   323.2,
B 325.5,   327.8,   331.6,   334.7,   337.2,   339.2,   341.0,
C 342.5,   345.0,   347.0,   348.6,   350.0,   351.3,
D 285.6,   298.5,   306.7,   312.5,   316.9,   320.4,   323.3,
E 325.8,   327.9,   332.3,   335.5,   338.1,   340.3,   342.1,
F 343.7,   346.4,  348.5,   350.3,   351.8,   353.1,
G 282.8,   295.9,   304.2,   310.1,   314.7,   318.4,   321.5,
H 324.1,   326.4,   331.0,   334.5,   337.4,   339.7,   341.7,
I 343.5,   346.3,   348.6,   350.5,   352.2,   353.6,
```

ISP(20, 6, 5)

FIGURE III-39
Liquid Rocket Fuel Deck - Expansion Ratio Table

```
DATA NPC,NMR,NISP/5,6,26/
                    ↑     ↑    ↖
                  #PCX  #MRX      #ISPX
```

```
                                                   PCX
DATA TAEXR / 20., 100., 300., 500., 2000.,  }
1 2.0, 2.2, 2.4, 2.6, 2.8, 3.0,              }  MRX
2 264.0, 270.0, 276.0, 282.0, 288.0, 293.0, 298.0, 303.0, 308.0,  } ISP
3 312.0, 316.0, 320.0, 324.0, 326.0, 329.0, 332.0, 335.0, 338.0,
4 340.0, 342.0, 344.0, 346.0, 348.0, 350.0, 352.0, 354.0,
```

XER(1,1,1)

```
1 00.00, 00.00, 00.00,  4.36,  5.40,  6.42,  7.81,  9.72, 12.33,
2 15.20, 19.05, 24.31, 31.82, 36.58, 45.71, 58.18, 75.72, 99.99,
3  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
4  0.0 ,  0.0 ,  0.0 ,  4.33,  5.30,  6.18,  7.48,  9.13, 11.32,
5 13.63, 16.61, 20.64, 26.03, 29.48, 35.75, 44.06, 55.00, 69.47,
6 82.31, 98.33,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
7  0.00,  0.00,  0.00,  4.53,  5.46,  6.37,  7.60,  9.19, 11.23,
8 13.31, 15.93, 19.36, 24.02, 26.88, 32.00, 38.41, 46.67, 57.69,
9 67.00, 77.78, 91.54,  0.00,  0.00,  0.00,  0.00,  0.00,
A  0.00,  0.00,  0.00,  4.88,  5.79,  6.86,  8.07,  9.70, 11.78,
B 13.89, 16.54, 19.83, 24.22, 26.86, 31.43, 37.17, 44.47, 53.93,
C 61.36, 70.53, 81.25, 94.62,  0.00,  0.00,  0.00,  0.00,
D  0.00,  0.00,  4.39,  5.30,  6.33,  7.51,  8.94, 10.72, 13.03,
E 15.31, 18.16, 21.77, 26.18, 28.82, 33.50, 39.20, 46.32, 55.33,
F 62.50, 70.95, 80.59, 92.67,  0.00,  0.00,  0.00,  0.00,
G  0.00,  0.00,  4.84,  5.76,  7.04,  8.30,  9.93, 12.00, 14.73,
H 17.41, 20.80, 24.80, 29.87, 33.06, 38.46, 44.78, 52.73, 62.31,
I 70.00, 78.70, 88.95,  0.00,  0.00,  0.00,  0.00,  0.00,
```

XER(26,6,1)

FIGURE III-39 (Continued)

XER(1,1,2)

```
1  0.00,  0.00,  0.00,  0.00,  5.04,  5.93,  7.33,  9.10, 11.51,
2 14.16, 17.70, 22.71, 29.44, 34.05, 42.67, 54.55, 70.00, 93.00,
3  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
4  0.00,  0.00,  0.00,  0.00,  4.82,  5.66,  6.81,  8.23, 10.21,
5 12.31, 15.04, 18.63, 23.65, 26.72, 32.39, 39.74, 49.64, 63.16,
6 74.67, 89.23,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
7  0.00,  0.00,  0.00,  0.00,  4.87,  5.67,  6.74,  8.04,  9.85,
8 11.71, 14.00, 17.13, 21.22, 23.66, 28.17, 33.80, 41.11, 50.80,
9 58.80, 68.50, 80.00, 95.00,  0.00,  0.00,  0.00,  0.00,
A  0.00,  0.00,  0.00,  4.20,  5.12,  5.89,  7.04,  8.34, 10.09,
B 11.87, 14.13, 16.96, 20.60, 22.98, 26.97, 31.85, 37.95, 45.94,
C 52.59, 60.00, 69.52, 80.67, 94.62,  0.00,  0.00,  0.00,
D  0.00,  0.00,  0.00,  4.61,  5.52,  6.42,  7.60,  9.08, 10.96,
E 12.84, 15.13, 18.00, 21.01, 23.94, 27.86, 32.59, 38.33, 45.59,
F 51.72, 58.62, 66.96, 76.84, 88.75,  0.00,  0.00,  0.00,
G  0.00,  0.00,  4.14,  5.05,  5.97,  7.13,  8.43, 10.09, 12.26,
H 14.44, 17.07, 20.41, 24.49, 26.97, 31.17, 36.35, 42.30, 50.00,
I 56.45, 63.60, 71.91, 81.67, 93.13,  0.00,  0.00,  0.00.
```

XER(1,1,3)   XER(26,6,2)

```
1  0.00,  0.00,  0.00,  0.00,  4.88,  5.77,  7.09,  8.79, 11.14,
2 13.66, 17.10, 22.00, 28.52, 32.86, 41.00, 52.38, 67.78, 90.00,
3  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
4  0.00,  0.00,  0.00,  0.00,  4.56,  5.42,  6.44,  7.81,  9.69,
5 11.68, 14.24, 17.80, 22.43, 25.18, 30.65, 37.78, 47.14, 59.57,
6 70.67, 84.62,  0.00,  0.00,  0.00,  0.00,  0.00,  0.00,
7  0.00,  0.00,  0.00,  0.00,  4.52,  5.33,  6.24,  7.55,  9.22,
8 10.93, 13.09, 15.85, 19.60, 22.05, 26.17, 31.46, 38.25, 47.14,
9 54.80, 63.68, 75.00, 88.57,  0.00,  0.00,  0.00,  0.00,
A  0.00,  0.00,  0.00,  0.00,  4.71,  5.49,  6.43,  7.68,  9.28,
B 10.88, 12.91, 15.50, 18.82, 20.85, 24.51, 29.06, 34.62, 41.94,
C 47.81, 55.00, 63.50, 73.89, 86.43,  0.00,  0.00,  0.00,
D  0.00,  0.00,  0.00,  4.15,  5.06,  5.82,  6.92,  8.17,  9.83,
E 11.52, 13.37, 16.15, 19.39, 21.44, 24.78, 29.12, 34.29, 40.79,
F 46.18, 52.50, 59.64, 68.64, 78.95, 92.14,  0.00,  0.00,
G  0.00,  0.00,  0.00,  4.60,  5.51,  6.43,  7.62,  9.11, 10.98,
H 12.86, 15.19, 18.00, 21.77, 23.85, 27.57, 32.00, 37.40, 44.05,
I 49.44, 55.81, 62.92, 71.50, 81.67, 93.33,  0.00,  0.00.
```

XER(26,6,3)

FIGURE III-39 (Continued)

XER(1,1,4)

```
1  0.00,   0.00,   0.00,   0.00,   4.47,   5.57,   7.00,   8.75,  10.97,
2 13.50,  16.90,  21.71,  28.15,  32.38,  40.10,  51.82,  66.60,  89.50,
3 98.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,
4  0.00,   0.00,   0.00,   0.00,   4.46,   5.12,   6.40,   7.75,   9.52,
5 11.47,  13.94,  17.47,  22.03,  24.73,  30.00,  32.17,  46.30,  59.25,
6 69.50,  82.50,  98.00,   0.00,   0.00,   0.00,   0.00,   0.00,
7  0.00,   0.00,   0.00,   0.00,   4.52,   5.11,   6.00,   7.30,   8.94,
8 10.60,  12.73,  15.46,  19.05,  21.41,  25.25,  30.44,  37.10,  45.50,
9 52.75,  62.00,  75.00,   0.00,   0.00,   0.00,   0.00,   0.00,
A  0.00,   0.00,   0.00,   0.00,   4.60,   5.13,   5.95,   7.35,   8.95,
B 10.47,  12.41,  14.93,  18.10,  20.10,  23.50,  27.97,  33.50,  40.50,
C 46.25,  52.75,  62.22,  74.50,   0.00,   0.00,   0.00,   0.00,
D  0.00,   0.00,   0.00,   0.00,   5.00,   5.75,   6.66,   7.88,   9.43,
E 11.02,  12.97,  15.40,  18.45,  20.34,  23.50,  27.79,  32.50,  39.00,
F 44.00,  50.00,  58.00,  60.00,  02.00,   0.00,   0.00,   0.00,
G  0.00,   0.00,   0.00,   4.40,   5.00,   6.00,   7.35,   8.80,  10.47,
H 12.21,  14.39,  17.11,  20.43,  22.55,  25.55,  30.17,  35.25,  41.50,
I 46.00,  52.50,  60.50,  70.00,  82.50,   0.00,   0.00,   0.00,
```

XER(1,1,5)   XER(26,6,4)

```
1  0.00,   0.00,   0.00,   0.00,   4.15,   5.15,   6.67,   8.40,  10.69,
2 13.17,  16.50,  21.03,  27.50,  31.67,  39.50,  50.00,  64.50,  87.50,
3105.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,
4  0.00,   0.00,   0.00,   0.00,   4.00,   5.00,   6.10,   7.50,   9.14,
5 11.00,  13.40,  16.61,  20.97,  23.75,  29.00,  35.28,  44.10,  56.00,
6 68.20,  86.92,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,
7  0.00,   0.00,   0.00,   0.00,   4.00,   4.60,   5.55,   6.80,   8.38,
8  9.92,  11.90,  14.46,  17.90,  20.00,  23.75,  28.62,  34.80,  42.50,
9 49.25,  57.50,  69.50,  85.00, 105.00,   0.00,   0.00,   0.00,
A  0.00,   0.00,   0.00,   0.00,   4.00,   4.50,   5.50,   6.80,   8.15,
B  9.60,  11.41,  13.65,  16.70,  18.43,  21.50,  25.65,  30.50,  36.70,
C 41.75,  48.00,  56.25,  67.75,  85.00,   0.00,   0.00,   0.00,
D  0.00,   0.00,   0.00,   0.00,   4.50,   5.10,   6.00,   7.00,   8.45,
E  9.38,  11.59,  13.77,  16.56,  18.19,  21.10,  24.70,  29.00,  34.90,
F 39.50,  44.90,  50.75,  57.75,  67.62,   0.00,   0.00,   0.00,
G  0.00,   0.00,   0.00,   0.00,   4.50,   5.50,   6.50,   7.60,   9.29,
H 10.83,  12.70,  15.03,  17.92,  19.65,  22.50,  26.30,  30.75,  36.40,
I 40.80,  46.10,  52.20,  54.00,  67.62,   0.00,   0.00,   0.00
```

XER(26,6,5)

Should a new liquid propellant type be required, the user may select the number of values of PC, MR, and ER to be used, up to limits of 5, 6, and 20, respectively. The selected numbers are stored into COMMON through

$$COMMON/TABSEX/BLANK(3), NPCP, NMRP, NEXR$$

where NPCP, NMRP, and NEXR communicate the actual number of PC, MR, and ER, respectively, to be stored. The new ISP deck is then programmed into TAISP as follows:

$$TAISP(1)-(NPCP) \equiv PC(1)-(NPCP),$$

$$TAISP(NPCP+1)-(NPCP + NMRP) \equiv MR(1)-(NMRP),$$

$$TAISP\ (IA+1)-(IA + NEXR) \equiv ER(1)-(NEXR),$$

where   IA = NPCP + NMRP,

and $TAISP\ (IB+1)-(IB+IC) \equiv ISP\ (1, 1, 1)-(NEXR,\ NMRP, NPCP)$,

where   IB = NPCP + NMRP + NEXR,

and   IC = NPCP (NMRP)(NEXR).

The deck is thus stored with no gaps in data items.

      The second form of liquid fuel data required (expansion ratio versus ISP) is communicated to the propulsion sizing modules through the COMMON block defined by

$$COMMON/ROCLX/TAEXR(817).$$

The TAEXR array is shown in Figure III-39 to consist of the following components:

$$TAEXR(1)-(5) \equiv PCX(1)-(5),$$

$$TAEXR(6)-(11) \equiv MRX(1)-(6),$$

$$TAEXR(12)-(37) \equiv ISPX(1)-(26),$$

and $TAEXR(38)-(817) \equiv XER(1, 1, 1)-(26, 6, 5)$.

Should a new liquid propellant type be required, the user may select the number of values of PCX, MRX, and ISPX to be used, up to limits of 5, 6, and 26, respectively. The selected numbers are stored into CØMMØN through the packing method shown for the ISP table above, using

COMMON/TABSEX/NPC, NMR, NISP, BLANK(3)

where NPC, NMR, and NISP communicate the desired number of PCX, MRX, and ISPX, respectively, to be stored. The new expansion ratio deck is then programmed into TAEXR through XER.

5.2   Solid Propellant Input

Solid rocket sustainer propellant performance characteristics data are stored in BLOCK DATA modules. The HTPB propellant type is stored in the CGSM currently. Format of those data is parallel to that discussed above for liquid fuel data.

The solid propellant ISP data table is stored through DAT5. Those data which are presented are shown in Figure III-40. Data are communicated through the array TAISP and the following COMMON block:

CØMMØN/PINSØL/TAISP(719).

The TAISP array consists of the following components (see Figure III-40):

TAISP(1)-(2)   (Do not change).

TAISP(3)-(19) $\equiv$ PC(1)-PC(17)

TAISP(20)-(39) $\equiv$ ER(1)-ER(20),

TAISP(40)-(379) $\equiv$ ISP(1)-ISP(340),

and   TAISP(380)-(719)   (Do not change).

Should a new solid propellant type be required, the user may select the number of values of PC and ER to be used, up to limits of 17 and 20, respectively. The selected numbers are stored into COMMON using:

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FIGURE III-40
Solid Rocket Fuel Deck - **Specific Impulse** Table

#PC

#ER

DATA NPCP,NEXR/17,20/

(Do not change)

DATA TAISP /1.0, 2.0, _____

120.,	30.,	40.,	50.,	75.,	100.,	150.,	200.,	300.,	400.,	} PC
2500.,	750.,	1000.,	1250.,	1500.,	1750.,	2000.,				

34.,	6.,	8.,	10.,	12.,	14.,	16.,	18.,	20.,	25.,	30.,	} ER
435.,	40.,	45.,	50.,	60.,	70.,	80.,	90.,	100.,			

ISP(1,1)

5	254.6,	266.7,	274.6,	290.5,	276.0,
6	288.9,	292.0,	294.7,	297.0,	301.8,
7	305.4,	308.4,	310.9,	313.0,	314.8,
8	317.9,	320.5,	322.6,	324.4,	325.9,
9	255.6,	267.7,	275.5,	291.4,	288.0,
A	289.9,	292.9,	295.5,	297.9,	302.6,
B	306.2,	309.2,	311.6,	313.9,	315.6,
C	318.7,	321.2,	323.2,	325.0,	325.6,
D	256.3,	268.4,	276.2,	292.0,	289.5,
E	290.4,	293.5,	296.1,	298.4,	303.1,
F	306.9,	309.7,	312.2,	314.3,	315.1,
G	319.2,	321.6,	323.7,	325.5,	327.0,

ISP(20,3)

ISP(1,4)

1	256.9,	268.9,	276.7,	292.5,	274.9,
2	290.9,	293.9,	296.6,	298.9,	303.6,
3	307.2,	310.1,	312.6,	314.7,	315.5,
4	319.5,	322.0,	324.0,	325.8,	327.3,
5	257.9,	269.9,	277.5,	293.4,	288.0,
6	291.6,	294.7,	297.4,	299.7,	304.3,
7	307.9,	310.8,	313.3,	315.3,	317.1,
8	320.2,	322.4,	324.6,	326.4,	327.9,
9	259.4,	270.4,	279.1,	293.9,	289.5,
A	292.2,	295.2,	297.9,	300.2,	304.8,
B	308.4,	311.3,	313.7,	315.9,	317.6,
C	320.6,	323.0,	325.0,	326.7,	329.3,
D	259.2,	271.3,	278.9,	294.6,	289.2,
E	292.9,	296.0,	298.6,	300.9,	305.5,
F	309.0,	311.9,	314.3,	316.4,	319.2,
G	321.1,	323.5,	325.5,	327.3,	329.7,

ISP(20,7)

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FIGURE III-40 (Continued)

ISP(1,8)

1	253.5,	271.8,	279.4,	285.2,	287.7,
2	273.4,	276.4,	299.1,	301.3,	305.0,
3	309.5,	312.3,	314.7,	315.8,	318.5,
u	321.5,	323.9,	325.9,	327.6,	329.1,
5	260.5,	272.5,	290.1,	295.8,	290.4,
6	294.9,	297.1,	299.7,	301.9,	305.5,
7	310.0,	312.9,	315.3,	317.3,	319.1,
8	322.0,	324.4,	325.3,	328.0,	329.5,
9	261.1,	273.0,	280.6,	296.3,	290.8,
A	294.5,	297.5,	300.1,	302.4,	306.9,
B	310.4,	313.3,	315.6,	317.6,	319.4,
C	322.3,	324.7,	326.6,	328.3,	329.8,
D	261.5,	273.4,	281.0,	286.5,	291.2,
E	294.8,	297.8,	300.4,	302.7,	307.2,
F	310.7,	313.5,	315.9,	317.9,	319.5,
G	322.5,	324.9,	326.8,	328.5,	330.0,

ISP(20,11)

ISP(1,12)

1	252.2,	274.0,	281.6,	287.2,	291.7,
2	295.3,	298.4,	300.9,	303.2,	307.7,
3	311.2,	314.0,	316.3,	318.3,	320.0,
u	322.9,	325.3,	327.2,	328.9,	330.3,
5	262.6,	274.4,	281.9,	287.5,	292.0,
6	295.7,	298.7,	301.3,	303.5,	308.0,
7	311.5,	314.3,	315.6,	318.6,	320.3,
8	323.2,	325.5,	327.4,	329.1,	330.5,
9	262.9,	274.7,	282.1,	287.8,	292.3,
A	295.9,	299.0,	301.5,	303.7,	308.2,
B	311.7,	314.5,	316.8,	318.8,	320.5,
C	323.4,	325.7,	327.6,	329.3,	330.7,

ISP(20,14)

ISP(1,15)

1	263.2,	275.0,	282.5,	288.0,	292.5,
2	295.1,	299.1,	301.7,	303.9,	308.4,
3	311.6,	314.6,	317.0,	318.9,	320.5,
u	323.5,	325.8,	327.7,	329.4,	330.8,
5	263.4,	275.2,	282.7,	288.2,	292.7,
6	295.3,	299.3,	301.9,	304.1,	308.5,
7	312.0,	314.9,	317.1,	319.1,	320.8,
8	323.4,	325.9,	327.9,	329.5,	330.9,
9	263.6,	275.3,	282.9,	288.4,	292.8,
A	296.4,	299.4,	302.0,	304.2,	308.7,
B	312.1,	314.9,	317.2,	319.2,	320.9,
C	323.7,	325.0,	327.9,	329.6,	331.0.

D - (Don't change the next 340 values)/

ISP(20,17)

CØMMØN/TABSET/BLANK1, NPC, NISP, BLANK2, NPCP, NEXR

where BLANK1 = BLANK2 = 2, and where NPCP and NEXR are the user
selected numbers for chamber pressure and expansion ratio, respectively.
The new ISP deck is then programmed into TAISP as follows:

TAISP(1)-(2)   (Do not change),

TAISP(3)-(2+NPCP) $\equiv$ PC(1)-PC(NPCP),

TAISP(IA+1)-(IA+NEXR) $\equiv$ ER(1)-ER(NEXR),

where   IA-2+NPCP,

and   TAISP(IB+1)-(IB+IC) $\equiv$ ISP(1)-ISP(IC),

where   IB = 2+NPCP + NEXR,

and   IC = NPCP (NEXR).

The deck is thus stored with no gaps in the data.

Solid propellant expansion ratio data are communicated through the
COMMON block (see Figure III-41 for prestored values):

CØMMØN/CØMP/TAEPS(505).

The TAEPS array consists of the following components:

TAEPS(1)—(2)   (Do not change),

TAEPS(3)-(11) $\equiv$ PCX(1)-(9),

TAEPS(12)-(37) $\equiv$ ISPX(1)-(26),

TAEPS(38)-(271) $\equiv$ XER(1,1)-(26,9),

and   TAEPS(272)-(505)   (Do not change).

Should a new propellant type be required, the user may select the num-
bers of values of chamber pressure (PCX) and specific impulse (ISPX) to
be used, up to limits of 9 and 26, respectively. Those numbers are labeled
NPC and NISP in the COMMON block (TABSET) discussed above. Expansion
ratio data for the new propellant type are then packed into TAEPS in the
manner shown above for the ISP table.

FIGURE III-41
Solid Rocket Fuel Deck - Expansion Ratio Table

#PCX   #ISPX

DATA NPC,NISP,/9,26/   (Do not change)

DATA TAFPS /(1.0, 2.0,)

```
1 100.,    300.,    500.,    750.,  1000.,  1250.,  1500.,  1750.,  2000.,   } PCX
```

```
2 254.,  261.0,   267.0,   272.0,   276.0,   279.0,   281.0,   282.0,    } ISPX
3 284.0,286.0,   288.0,   290.0,   292.0,   294.0,   296.0,   298.0,
4 300.0,302.0,   304.0,   306.0,   308.0,   311.0,   315.0,   320.0,
5 320.0,331.0,
```

XER(1,1)

```
6  0.00,   4.43,   5.43,   6.42,   7.45,   8.31,   9.00,   9.34,
7 10.04,  10.91,  11.78,  12.81,  13.89,  15.20,  16.59,  18.09,  19.83,
8 21.96,  24.13,  26.67,  29.44,  34.48,  43.10,  58.00,  80.00,   0.00,
9  0.00,   4.07,   5.08,   5.92,   6.92,   7.71,   8.32,   8.67,
A  9.37,  10.09,  10.96,  11.83,  12.89,  14.00,  15.29,  16.69,  18.27,
B 20.11,  22.28,  24.46,  27.14,  31.72,  39.38,  53.70,  73.16,   0.00,
```
                                                          XER(26,2)

XER(1,3)

```
1  0.00,   0.00,   4.92,   5.76,   6.68,   7.47,   8.00,   8.36,
2  9.09,   9.82,  10.64,  11.49,  12.44,  13.56,  14.80,  16.15,  17.69,
3 19.39,  21.44,  23.67,  26.14,  30.54,  38.13,  51.38,  70.53,   0.00,
4  0.00,   0.00,   4.81,   5.66,   6.53,   7.32,   7.84,   8.14,
5  8.86,   9.57,  10.36,  11.24,  12.17,  13.28,  14.45,  15.74,  17.28,
6 18.96,  20.89,  23.11,  25.43,  29.71,  37.17,  50.00,  68.75,   0.00,
7  0.00,   0.00,   4.75,   5.59,   6.43,   7.23,   7.76,   8.04,
8  8.75,   9.46,  10.22,  11.11,  12.00,  13.08,  14.20,  15.53,  17.00,
9 18.64,  20.56,  22.78,  25.00,  29.29,  36.52,  49.12,  67.83,   0.00,
```

XER(1,6)   XER(26,5)

```
1  0.00,   0.00,   4.69,   5.54,   6.35,   7.16,   7.70,   7.97,
2  8.67,   9.37,  10.09,  10.98,  11.87,  12.94,  14.06,  15.35,  16.80,
3 18.45,  20.33,  22.56,  24.78,  29.00,  36.09,  48.53,  66.96,   0.00,
4  0.00,   0.00,   4.64,   5.49,   6.27,   7.07,   7.60,   7.87,
5  8.55,   9.27,  10.00,  10.89,  11.78,  12.83,  13.94,  15.27,  16.69,
6 18.27,  20.11,  22.33,  24.56,  28.82,  35.83,  48.24,  66.52,   0.00,
7  0.00,   0.00,   4.61,   5.46,   6.21,   7.01,   7.55,   7.81,
8  8.47,   9.20,   9.93,  10.80,  11.69,  12.72,  13.83,  15.13,  16.54,
9 18.09,  19.91,  22.16,  24.43,  28.57,  35.44,  47.65,  66.09,   0.00,
A  0.00,   0.00,   4.58,   5.44,   6.18,   6.97,   7.50,   7.76,
B  8.40,   9.13,   9.85,  10.73,  11.64,  12.67,  13.78,  15.07,  16.46,
C 18.00,  19.82,  22.00,  24.22,  28.38,  35.22,  47.35,  65.65,  100.0,
```

D - (Don't change the next 234 values)
                                                    XER(26,9)

3.   OPTIONAL DETAILED OUTPUT

Design, performance, and sizing data may be output at each
major step in the concept generation process. Details are available during
propulsion system sizing, aerodynamics evaluations, and trajectory simu-
lations. Available data are discussed in the following paragraphs and are
listed sequentially at the end of this section.

All NAMELIST input list parameters are assigned prestored values
under the CGSM input method. The input card decks need reference only
those lists and list parameters which are to be changed away from their pre-
stored values for each specific JOB. Two forms of printout are provided
to identify input. The first output form is a card image printout of the in-
put card deck, while the second form is a formatted printout of the complete
input list showing values (prestored or input) for all list parameters. Those
output sets may be examined by reference to the sample problem (see
Section VII).

The complete input card deck is read and printed as the first step
of CGSM execution unless the first four columns of the PCODE card are
left blank. Each card is assigned a sequential card number by the CGSM
as it is read. That card number and the contents of the card are then printed
on the output file to provide a permanent record of each JOB's input.

Under the CGSM input scheme, the number of list parameters
actually input through the card deck for a given JOB may be a small fraction
of the total number of parameters in the list. The parameters which are
allowed to default to their input values are as much an input to the JOB as
those which are entered through the card deck, however. The process of
combining input deck values with prestored values by the CGSM has the
following steps:

(1)   Load prestored values into list parameter locations.

(2)   Read the input deck and print card images.

(3)   Load input deck values into referenced list parameters, replacing their prestored values. Parameters not referenced retain their prestored values.

Output of all list parameters following step 3 results in printout of card input and default values as well. That output option is available to the user if INPRIN=1 is input through the NAM1 list (see Figure III-12). Several variations of format are available, as can be seen by reference to the NAM1 list (see Figure III-12). All NAMELIST parameters of all lists which are referenced by the input deck are printed when INPRIN=1, even if a blank list is input.

The various specialty submodels are linked together by a set of executive modules and logic blocks. Optional messages are printed by the executive after each major synthesis step to improve output traceability. Summary data are printed at selected points during the synthesis, as can be seen by reference to the sample problem (see Section VII). Certain user options affect the synthesis flow, and, therefore, affect labeling messages. For example, if the performance step is bypassed through the NAMBYP list (see Figure IV-27), steps g, h, i, and j are bypassed and their associated executive output is suppressed. Such excursions have been assigned executive labeling messages parallel to those already discussed. Executive labeling is suppressed if IPSM=IAIR=IVP=0 in the NAM1 list (see Figure III-12).

3.1   Relative Cost Output

Output from the Relative Cost Model consists of a summary of RDT&E and first unit production cost items as well as total (combined) cost. That output is shown on Figure IV-4 (facing pages have been omitted for this figure since it is assumed to be self-explanatory). Further discussion

of cost output is found in Volume V. The data of Figure IV-4 are printed if ICOST is input as -1 in the NAM1 list (see Figure III-12) and is omitted if ICØST = 0.

3.2   External Booster Sizing

Detailed data may be output during the external booster sizing step if IPSM = -1 in NAM1. The data are listed and defined in Figures IV-5 and IV-6. A discussion of the booster sizing methodology is included in Appendix D, Vol. IIID.

3.3   Inlet Sizing

Design and weights data may be printed during the inlet sizing step if airbreathing missiles are generated and if IPSM = -1 in NAM1. Inlet data are listed and defined in Figure IV-7. A discussion of inlet sizing methodology is found in Appendix E, Vol. IIID.

3.4   Ramjet Sustainer Sizing

Details on ramjet propulsion system design and sizing are available as output for each concept if IPSM = -1 or IPSM = -2 in the NAM1 list. The data include a missile summary data list (Figure IV-8), a ramjet fuel system summary (Figure IV-9), data on integral ramjet booster/combustor sizing (Figure IV-10), a summary of ramjet nozzle design and weights (Figure IV-11), and, finally, a list of combustor/nozzle parameters for non-integral ramjets (Figure IV-12). Ramjet methodology is discussed in Appendix F, Vol. IIID.

3.5   Solid/Liquid Rocket Sustainer Sizing

Sizing, design, and performance parameters available for output during rocket sustainer sizing are defined in Figures IV-13 through IV-15. The first two figures list solid rocket details (see also Appendix C, Vol. IIIC), while Figure IV-15 presents data for the liquid rocket (see also

Appendix C, Vol. IIIC). Output is suppressed when IPSM = 0 and is enabled when IPSM = -1 in the NAM1 list.

3.6   Turbojet Sustainer Sizing

Sizing, design, and performance parameters available for the turbojet sustainer system are defined in Figures IV-16 and IV-17. Output of those lists is suppressed when IPSM = 0 and is enabled when IPSM = -1 in the NAM1 list. A detailed discussion of turbojet methodology is included in Appendix G, Vol. IIID.

3.7   Aerodynamic Output

Tables of drag and lift coefficients versus Mach number and altitude are output when IAIR = -1 in the NAM1 list. Those tables are defined in Figure IV-18. Aerodynamics methodology is documented in Appendix A, Vol. IIIB.

3.8   Trajectory Simulation and Vehicle Performance

Time histories of trajectory variables are printed in a columnar format in two tables, as shown in Figures IV-19 and IV-20, if IVP = -1 in the NAM1 list. The name of the variable and its units appear at the top of each column on each page of output. Definitions of the variables follow for each figure. An iteration is required in the performance model to maximize the concept's cruise phase range, and, thereby, maximize overall missile range. The optional output during that iteration is included on Figure IV-20. The vehicle performance model is discussed in detail in Appendix B, Vol. IIIB.

FIGURE IV-4

CGSM OUTPUT - RELATIVE COST DATA

CONFIGURATION   3

RELATIVE COST SUMMARY
(COSTS IN THOUSANDS OF 1974 DOLLARS)

MISSILE DEVELOPMENT COSTS		74036.56
AIRFRAME + INTEGRATION	20817.17	
PROPULSION SYSTEM	5042.37	
GUIDANCE SYSTEM	17287.19	
CONTROLS SYSTEM	7690.45	
WARHEAD	23199.42	
MISSILE FIRST UNIT PRODUCTION COSTS		740.82
AIRFRAME + INTEGRATION	326.96	
PROPULSION SYSTEM	66.35	
GUIDANCE SYSTEM	252.54	
CONTROLS SYSTEM	91.90	
WARHEAD	3.06	
TOTAL COST THROUGH FIRST UNIT PRODUCTION		74777.38

FIGURE IV-5

CGSM OUTPUT - EXTERNAL BOOSTER SIZING

BOOSTER SIZING DETAILS		WEIGHTS		PERFORMANCE	
PROPELLANT	415.98	THRUST	111809.25	CF	1.547
INERTS	384.47	THRUST/WT	14.41		
TOTAL MOTOR	800.45	DELTA VI	407.153	CF VACUUM	1.664
PAYLOAD	6960.00	I TOTAL	95551.75	BURN TIME	0.855
LAUNCH WT	7760.38	ISP DEL	229.736	BURN RATE	3.139
BURN OUT WT	7344.46	ISP VAC	247.168	PORT/THROAT	1.500
DIMENSIONS		PRESSURES		MISCELLANEOUS	
DIAMETER	19.800	DESIGN	1284.00	MMF	0.5197
LT CYL	20.583	CHAMBER	1070.00	VOL LOADING	0.5934
LT FWD HEAD	4.950	AMBIENT	10.00	(I TOTI/WT	12.31
LT NOZZLE	43.656	EXIT	0.00	NOZ CANT ANG	0.0
SKIRT EXTN	0.0				
TOTAL LT	79.189				

BREAKDOWN OF CHAMBER DESIGN   MATERIAL, RENE 41

	FORWARD	CYLINDER	AFT	TOTAL
WEIGHTS				
STRUCTURE	12.134	59.015	8.990	80.139
INSULATION	3.087	27.360	4.083	34.529
BOSS	9.432		0.0	9.432
IGNITER	2.159			2.159
SKIRTS	16.000		3.859	19.859
CONSTANTS	0.0	0.0	0.0	0.0
TOTAL CHAMBER	42.811	86.375	16.932	146.118
PROPELLANT	28.286	373.769	13.866	415.981
NOZZLE WEIGHT				238.350
TOTAL WEIGHT	71.096	460.144	30.798	800.449
THICKNESS				
INSULATION				
AVG	0.05000	0.09000	0.09000	
MAX		0.09000	0.09000	
CASE	0.10410	0.10410	0.10410	

ULTIMATE CASE STRENGTH 153610.   YIELD CASE STRENGTH 122108.
THE MINIMUM ALLOWABLE CASE THICKNESS WAS 0.07000

SECTION V

USER OPERATING PROCEDURES

1. GENERAL

This section defines the operating procedures necessary for utilization of the Concept Generation and Screening Model. The CGSM source deck consists of more than 28,000 cards. To facilitate small modifications with a minimum of recompilation, it is recommended that the load module be placed on a users' library. This will also greatly reduce card handling requirements for production run utilization. All figures referenced in this section are added at the end of the text.

1.1 CGSM Compilation and Link Edit to a Users' Library

The IBM System 360/65 will compile the CGSM in approximately 21 minutes of CPU time. Figure V-1 shows the typical JCL setup required for CGSM compilation, link edit and placing the load module on a private disk pack. A listing of the OVERLAY and INSERT cards is presented in Figure V-2. If the CGSM load module requires subsequent modification, only the subroutine(s) that were changed need to be loaded as "CGSM Fortran Source Decks."

Link overlay is used in the CGSM to reduce computer core storage requirements at execution time. A non-overlay load module would exceed operational core limitations on the DIAMS IBM/360-65 computer subsystem. The link overlay module including I/O buffers is limited to a region less than 320 kilobytes storage.

There are currently 12 nodes in the CGSM overlay structure. These nodes separate the various models and selected functions within the models into 43 segments. Subroutines and labeled COMMON blocks included in each segment are shown in Figure V-2.

1.2 File Structure

The CGSM uses the data set reference numbers defined in this section. Data set reference number 5 is for card reader input to the program. The file is defined by FT05F001 DD *. Data set reference number 6 is for printed output. The file is defined by FT06F001 DD SYSOUT = A. Data set reference number 7 is punched card output. The file is defined by FT07F001 DD SYSOUT = B.

Data set reference number 9 is used for temporary storage of input card images during the card image printout step. The JCL required to create the data set at execution time is shown on Figure V-3.

Data set reference number 11 is for direct access I/O during program execution. The FORTRAN *Define File* statement and the JCL required to create the data set at execution time are shown in Figure V-3. File 11 is a temporary data set for direct access input/output of basic table data. Structuring of that scratch disk file is not directly available to the user.

Data set reference number 12 is for direct access I/O during program execution. The FORTRAN Define File statement and the JCL required to create the data set at execution times are shown in Figure V-3. File 12 is a temporary direct access data set held only for the duration of the job under execution, and used for data communication between the CGSM generation and screening links. As each concept is generated, its sizing, design, performance, and worth details are stored on File 12. Those data are then recalled when required for screening purposes. The length of File 12 is set in the MAIN module of the CGSM and by the JCL of Figure V-3. The parameter KSAVPL should be set in the MAIN to a desired maximum number of concepts to be generated and screened. Each concept occupies one record, so that the number of records on File 12 should then be made to agree with the choice of KSAVPL.

1.3   User's Library

The JCL shown in Figure V-1 defines the User's Library as the partitioned data set SYS1.DS5CSEAA on the private disk pack VOL=SER= RIPTIDE. The CGSM load module is stored under the member name CMCGSM.

1.4   CGSM Execution

Figure V-4 defines a typical IBM System 360/65 JCL and deck setup required for executing a CGSM load module resident on a user's library. Card input only is used, while output may be printed or punched on cards.

FIGURE V-1

CGSM COMPILATION AND LINK EDIT TO
A USER'S LIBRARY

```
//HJ2013    JOB (C295,5438,,,,,,,,65,F03-0001,UNC,03),            X
//          RIPTIDE,1SGLEVEL=1
//STEP1  EXEC /FORTHCL,PARM.FORT='ID,NOMAP',                      V
//          REGION.FORT=300K,                                     X
//          PARM.LKED='OVLY,LET,MAP,LIST,SIZE=(200K,60K)',        X
//          REGION.LKED=212K
//FORT.SYSLIN DD SPACE=(CYL,(35,1))
```

TAPE INPUT
```
      //FORT.SYSIN DD DSN=CGSM1,UNIT=SYST9,VOL=SER=002923,        X
//              DCB=(DEN=2,BUFNO=1,RECFM=FB,LRECL=80,BLKSIZE=32000), X
//              DISP=(OLD,KEEP),LABEL=(,BLP)
```

OR

CARD INPUT
```
      //FORT.SYSIN  DD  *         PUT FORTRAN SOURCE DECKS AFTER THIS
      (SOURCE CARDS)
      /*
```

```
//LKED.SYSLMOD DD DSN=SYS1.DS5CSEAA,UNIT=2314,VOL=SER=RIPTDE,DISP=OLD, X
//              SPACE=(CYL,(5,5))
//LKED.SYSIN  DD  *
          INCLUDE SYSLMOD(CMCGSM)  ←

      (OVERLAY/INSERT  CARDS)

      ENTRY MAIN
              NAME CMCGSM(R)
  /*
```

FOR UPDATES ONLY

FIGURE V-2

OVERLAY/INSERT SPECIFICATION CARDS

```
OVERLAY ALPHA
        INSERT  SORTCM,LEVCM,LEVEL1
OVERLAY ALPHA
        INSERT  TBASIC,WCRD11,WBASIC,WRITRX,WMAT3
        INSERT  SETUP1,SETUP3,WRT1
        INSERT  NEMWTH,VALREC
        INSERT  DATA2,TF1102
        INSERT  INVRT
        INSERT  RJINPT
        INSERT  INCOST
        INSERT  CZAZA
OVERLAY ALPHA
        INSERT  PROTC
        INSERT  EXPDAT
OVERLAY ALPHA
        INSERT  SUPRCM
        INSERT  CDINLT
        INSERT  THETA
        INSERT  CHECK,GUESS
        INSERT  ISEN,TLU1,TLU2
        INSERT  FASTF,LINE,BLINE
        INSERT  DTRGET,MACHAC,RGAMER
        INSERT  FUNOVR
        INSERT  EXCLLD
        INSERT  RKBLK
OVERLAY BETA
        INSERT  PAYLCD
        INSERT  YNOSE
        INSERT  SKNWT
        INSERT  AFROWT,SURF
        INSERT  PACKER
        INSERT  COSTWT
        INSERT  CCST
        INSERT  AAICST,GUCCST,CTCCST
        INSERT  WHCOST
        INSERT  PEBCST
        INSERT  PSRCST,PLRCST,PTJCST,PIRCST,PARCST
        INSERT  WORTH
OVERLAY BETA
        INSERT  ADM
        INSERT  AFRMCD
        INSERT  BLKQ,WLCC,XYZ
        INSERT  XXX,XXXXX
        INSERT  ARINDX,TWY,TWX,TWL,SUMLIF
        INSERT  SUMOUT,SAVTIM,FIXUP,FIX,WIV
OVERLAY GAMMA
        INSERT  BLTGEC,WRTCUT
OVERLAY GAMMA
        INSERT  DRAG,BLTWC,FRCTN
        INSERT  BCOSTC
        INSERT  ZZZ
OVERLAY GAMMA
```

FIGURE V-2 (Cont'd.)

```
                INSERT  LIFT
                INSERT  AA
      OVERLAY  XI
                INSERT  INLIFX
                INSERT  LIFT1,LIFT2
      OVERLAY  XI
                INSERT  LIFT3,LIFT4
      OVERLAY  XI
                INSERT  LIFT5
                INSERT  BDYLPM,FMCMAT,CLINE
      OVERLAY  BETA
                INSERT  PSM
                INSERT  MATLS
      OVERLAY  KAPPA
                INSERT  FASTS
      OVERLAY  OMEGA
                INSERT  SOLROC
                INSERT  SOLSV,COMP,PINSOL
                INSERT  TABSET
      OVERLAY  OMEGA
                INSERT  ROCLIC,ROCLX,ROCL
                INSERT  TABSFX
      OVERLAY  KAPPA
                INSERT  PROPXX
                INSERT  PROPRJ
                INSEPT  NOZEX
                INSERT  SUSMAS,FMBPAK
                INSERT  ZELSPR,ZCYLLL,ZCYLHH,ZCCNHH,ZSPRLL,ZELPLL
                INSERT  ZELPSS,ZSPRSS
                INSERT  SURVD,EXTRJ
                INSERT  NOZMP,EXCWT
                INSERT  CCDERJ,ARRAY
      OVERLAY  DELTA
                INSERT  BEXEC
                INSERT  EXBCO
                INSERT  SDUCER
                INSERT  CURVE,CURVIC
      OVERLAY  DELTA
                INSERT  BOOST
                INSERT  RAMNOZ,AMACH
      OVERLAY  DELTA
                INSERT  INLETP
      OVERLAY  DELTA
                INSERT  RJDES,AM2X,FARGET
                INSERT  ORDES,EXRAM,RJWT
      OVERLAY  DELTA
                INSERT  XALPHA
                INSERT  SURVEY
                INSERT  XNL
      OVERLAY  PSI
                INSERT  PROP1
      OVERLAY  PSI
                INSERT  INLIFT
      OVERLAY  ETA
                INSERT  LXFT1,FASTX
```

FIGURE V-2 (Cont'd.)

```
OVERLAY ETA
      INSERT LXFT2
OVERLAY ETA
      INSERT LXFT3
OVERLAY KAPPA
      INSERT TURBO
      INSERT INLET
OVERLAY ZETA
      INSERT WATE,STORE1,STORE2
      INSERT INLEXP
      INSERT BLKTJ,BLKTX
OVERLAY ZETA
      INSERT VEHPER
      INSERT STDATA
      INSERT DERIV,MAINS
      INSERT AIR1
      INSERT DSLINE,RUNGEK,SLINE,TPROP
      INSERT XALPH1
      INSERT XALPH2
      INSERT OUTPUT,ERRCUT
      INSERT CIBLK,AIRBLK
      INSERT BCDBLK,PIBLK,IFBLK,PSBLK,IPSBLK
      INSERT CRLK,CUTBLK
OVERLAY NU
      INSERT PROP11
OVERLAY NU
      INSERT TJPER
      INSERT GENENG,ENGBAL,ERRCX,GUESX
      INSERT THERMO,PROCCN,PARABO
      INSERT POINT,LOOPPR
      INSERT ERER,TERPLC
      INSERT THCOMP,SEARCH,AFGUIR
      INSERT THTURB,MAPBAC
OVERLAY TAU
      INSERT PUTIN,ZERC,CCINLT,RAN,RAN2,ATMOS
OVERLAY TAU
      INSERT MATRIX,PERFF,CUTPAT,FRASHC
      INSERT CONOUT
OVERLAY TAU
      INSERT COFAN,FAN
OVERLAY TAU
      INSERT COCCMP
OVERLAY TAU
      INSERT COCOMB,CCMB
OVERLAY TAU
      INSERT COLPTB,LTURB
OVERLAY TAU
      INSERT FRTOSC,FASTBK
OVERLAY TAU
      INSERT COMIX
OVERLAY TAU
      INSERT CCAFBN,ETAAB
OVERLAY TAU
      INSERT CCMNCZ
      INSERT CONVRG
      INSERT CCNDIV
```

FIGURE V-3

CGSM FILE DEFINITION

```
//GO.FT09F001 DD DSN=&&LGO9,UNIT=SYSDA,DISP=(NEW,PASS),              X
//              DCB=(,RECFM=FB,LRECL=80,BLKSIZE=1600),              X
//              SPACE=(CYL,(3,1))
```

DEFINE FILE 11(160,175,U,JD11)

```
//FT11F001 DD DSNAME=&&LDG11,UNIT=D3330,                            X
//              DCB=(,BUFNC=1,DSORG=DA,OPTCD=C,RECFM=FT),           X
//              DISP=(NEW,PASS),SPACE=(700,(160,10))
```

DEFINE FILE 12(500,300,U,JD12)

```
//FT12F001     DD DSNAME=&&LDG12,UNIT=D3330,                        X
//              DCB=(,BUFNO=1,DSORG=DA,OPTCD=C,RECFM=FT),           X
//              DISP=(NEW,PASS),SPACE=(1200,(500,10))
```

FIGURE V-4

CGSM EXECUTION JOB CONTROL LANGUAGE

```
//HJ0003    JOB (0295,5A3B,,,,,2,,65,F03-C001,UNC,03),                    X
//          RIPTIDE,MSGLEVEL=1
//JOBLIB   DD DSN=SYS1.DS5CSEAA,UNIT=2314,VOL=SER=RIPTDE,DISP=(SHR,PASS)
//CGSM      EXEC PGM=CMCGSM,REGION=320K,TIME=60
//SYSUDUMP  DD SYSOUT=A
//FT12FC01  DD DSNAME=&&LDG12,UNIT=SYSDA,                                 X
//          DCB=(,BUFNO=1,DSORG=DA,OPTCD=C,RECFM=FT),                     X
//          DISP=(NEW,PASS),SPACE=(1200,(500,10))
//FT11F001  DD DSNAME=&&LDG11,UNIT=SYSDA,                                 X
//          DCB=(,BUFNO=1,DSORG=DA,OPTCD=C,RECFM=FT),                     X
//          DISP=(NEW,PASS),SPACE=(700,(160,10))
//GO.FTC9F001 DD DSN=&&LGCS,UNIT=SYSDA,DISP=(NEW,PASS),                   X
//          DCB=(,RECFM=FB,LRECL=80,BLKSIZE=1600),                        X
//          SPACE=(CYL,(3,1))
//FTO6FC01  DD SYSOUT=A
//FTO7FC01  DD SYSOUT=B
//FTO5FC01  DD *
```

INPUT
DATA
CARDS

/*

SECTION VII

SAMPLE PROBLEM

1.   GENERAL

This section presents a sample CGSM problem selected to illus-
trate the use of the model, familiarize the user with output formatting,
and serve as a reference run for future checkout of the CGSM. A single
concept is generated and "screened" using the following configuration
options:

Nose Shape	-	Von Karman
Wing	-	Planar
Tail	-	Planar
Boattail	-	Yes
Booster	-	Dual External
Sustainer	-	Solid Rocket
Inlet	-	None

Optional detailed output data were requested for the single missile concept.
All tables and data lists referenced in the card input deck are printed out
in their entirety to show default as well as input values. A card image
listing of the input deck is output as the first step of CGSM execution.
The CGSM output listing is presented as Figure VII-1.

```
*     *     *     *         UNCLASSIFIED         *

SOLIC ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75         PAGE   1


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```

VIV-II-2

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75   PAGE   2

INPUT CARD IMAGES

```
 1.  *  *  *  *  *  UNCLASSIFIED  *  *  *  *  *  *
 2.  SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM  FEB 75
                                      OUTPUT CONTROL OPTIONS
 3.  ZIP  4  1
 4.  &NAM1
 5.  IAIR=-1,  INPRIN=1,  IPRP(1)=1,  IPRP(2)=1,  IPRP(3)=1,  IPSM=-1,
 6.  NPAGE=6, KFIL12=0,
 7.  IVP=-1,
 8.  ICOST=1,
 9.  IPSM=-2,
10.  &END
11.  ZIP  7  4  1
12.  TABLE NO.    2010000    74001  1      READ BASIC VARIABLES
13.  KVAR.NAME* * *NVAL  VALUE 1  VALUE 2  VALUE 3  VALUE 4  VALUE 5  VALUE 6
14.   1.  M.AREA      1   15.24
15.   2.  T.AREA      1    7.23
16.   3.  M.ASP.R.    1    1.
17.   4.  LT.PLC      1  118.
18.   5.  W/H WT      1  1000.
19.   6.  CONT.WT     1  195.
20.   7.  DIAMETER    1   28.
21.   8.  BOO.T/W     1   10.
22.   9.  MAX THR     1  10000.
23.  10.  ISP         1  285.
24.  11.  PCHAM       1  1500.
25.  12.  MIX R       1    1.
26.  13.  DUMMY       1    C.
27.  14.  DUMMY       1    0.0
28.  15.  CUMMY       1    0.
29.  16.  CUMMY       1    0.
30.  17.  WEIGHT      1  8000.
31.  -1
32.  TABLE TYPE
33.  CONSTANTS
34.  ZIP  8  6
35.  &NAMCST
36.  MTGUID=350, KGTYPE=22,
37.  &END
38.  ZIP  9  3
39.  &NAM3
40.  WORTH1=37.45,
41.  NRMAX=7,
42.  PVRMAX=10,25,40,50,64,75,1000,
43.  CWRMAX=-7.3,-4.7,-2.7,0.5,6.7,6.7,
44.  NVCR=4,
45.  PVVCR=1.2,1.5,1.5,2.4,
46.  CWVCR=0,2.5,4,5.4,
47.  NWTWH=3,
48.  PVWTWH=500,1000,2000,
49.  DWWTWH=-6.4,0,17.6,
50.  &END
```

VII-3

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM   FEB 75

INPUT CARD IMAGES

```
51. ZIP  4  8
52. &NAMCNF
53.   ALTV(1)=0., 10000.,       ARVT=1., FACTOR=0.6, FSOVCT=0., FSOVCW=0.,
54.   FSGVVT=0., GULT=10., ILUG=0, IPLANT=1, IPLANW=1, IWTS=3, NALT=2,
55.   NRM=9, PANWHT=25., PANWVT=20., PANWVI=50.,
56.   RL5=55., RMDES=2.,
57.   RMV(1)=0.4, 0.8, 0.9, 1.0, 1.2, 1.4, 1.6, 2.0, 3.0,
58.   RXINT=0.5, RXINW=0.5, SLET=45., SLEVT=60., SLEW=60.,
59.   STET=0., SIEVT=0., STEW=0., THETAC=0.165, TRAT=0.05,
60.   TRAVT=0.05, TRAW=0.C5, TRT=0.2, TRV=0.4, TRW=0.4, VTALCC=0.677,
61.   WOVAHT=6, WOVAST=2.4, WOVAT=6, WOVAVT=6, WOVAW=6, WTI=50, WWINGI=105,
62.   ZPOPT=1, ZSKINI=0.1, ZWSKIN=280.,
63. &END
64. ZIP  5  8
65. &NAM500
66.          ABM=0.0, AER=2., AFAT=1.5, AIT=0.09,          ASL=2.,
67.   ASM=1., ASWM=0., CASEM=2, CSTAR=5000., DENI=0.1615, CLFS=0.0, EAR=2,
68.   EPI=10., ETAX=0.9, FBM=1., FCWM=1., FER=2., FIT=0.1, FJ=0.97,
69.   FMPAH=0.5, FSL=0., FSULX=1.4, FSWM=0., FSYLX=1.2, GAM=1.18, GMAX=30.,
70.   PA=14.7, PBELL=1, PC=1000., PCM=2000., PHI=21., PSUB=0., RBOSS=0.5,
71.   RHOP=0.0628, RMASW=0., RMAW=0., RMCW=0., RMFSW=0., RMFW=0.,
72.   RMIN=0.3, RNBWM=2.42E-6, RNEC=6.8E-10, RNECC=2.864E-6, RNEC1=0.8,
73.   RNEC2=1., RNEC3=1.7, RNRM=5., RNRM=0., RNTM=1.216E-4, RNTMM=1.834,
74.   SAW=0.0, SEM=1.E7, TCASEF=900., TL=.1, TMIN=.07, TTH=45., VRFH=0.,
75. &END
76. ZIP  5  8  1
77. &NAMEXB
78.   C1=1.1, C2=1.1, C3=1.1, C4=2., C5=2., C6=2., CLEAR=2.5, EL=2,
79.   MYLRAM=2, RHOENT=.04, RHOEXT=.04, RHOIN=.065, RHOTHT=.05, RHCX=0.02,
80.   TEMPC=900., TENT=0.2, TEXIT=0.2, TEXTER=0.0, THETA=45., TINAFT=.25,
81.   TINS=0.25, THINC=0.06, TMIND=0.06, TTHROT=0.2, WHARMS=25., XSTAR=60.,
82. &END
83. ZIP  5II
84. &NAMSR
85.   AIAT=0.25, APAT=1.5, ETACF=0.97, EXPBR=0.82, PBELS=100.,
86.   PHINOZ=17., REAM=2, REFH=2, RHOISS=0.036, RHOMTL=0.283, RHOS=0.062,
87.   SIGMTL=260000., TIC=0.1, TRATIO=10., WMSOL=0.0,
88. &END
89. ZIP  615      1
90. &NAMVPM
91.   ALPMAX=7*15, ALTF=5*500,0,0,    ANZMAX=7*20,
92.   CON11=0.5,    COND1=20,0,
93.   CONI2=0,100,  COND2=-3,-3,
94.   CCNI4=0,100,  COND4=0,0,
95.   CCNI6=0,100,  COND6=-2,-2,
96.   CONI7=0,1000, COND7=-1,-1,
97.   FVALUE=0,-1.5,0,1,2,5,-1,0,
98.   GAMMAF=2*16,4*0,-1,
99.   ICONT=1,6,14,1,13,6,1,  IPTYPE=1,6*3,   ITERM=6,7,1,8,4,1,3,
100.  MYGEN=7*0, MODES=1,1,0,1,0,-1,-1, NAERO=1,6*2,
```

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INPUT CARD IMAGES

```
101.    SLOPE=7*0, TPHASE=0,3*100,C,100,0,  TTOTAL=7*10000,
102.    XMACH=7*1.2,             ZPRINT=7*0,
103.    ALTI=50., DALPH=.009, DALT=2000., DCFN=0.10, DELMAX=60., DHCL=10000.,
104.    DMACH=.05, DMIN=.001, DSTART=0.1, DVCL=100., EREF=5E-4, ERRFAC=5.,
105.    FARMAX=0, GAMMAI=20., GKG=1.C, GKV=0.001, GKVCRU=0.1, GTOPT=1.0,
106.    MQPT=0, NCPHAZ=5, NDPHAZ=2, NLPHAZ=7, RANGEI=0.0, RTCL=10., TIMEI=0.0,
107.    TPCMGN=0.0, TT4MAX=3900., VELI=50., XMACHI=0.0,
108.   &END
109. ZIP 11 1 1
110.   &SUPER
111.    ALTI=50., ART=2.67, BCANTA=0.0, BRAT=0.0, DIAFR=0.5, DVMULT=1.2,
112.    DVTOL=30., FINE=3., FRBT=0.75, IART=1, IARW=1, IBTL=1, ICNTRL=1,
113.    INWORL=0.,        ISURFT=1, ISURFW=1, ITHR=0, ITN=2, ITSECT=2,
114.    IWSECT=2, KINLET=1, KPROP=13, MAXNI=3, NW=1, NZLLRI=0, NZTEMP=0,
115.    VEOB=700., VL=50., WWISC= 0., XLBDY=0.0, XMACHI=0.0, ZXNB=2,
116.   &END
117. ZIP 11 3
118.   &NAMSCR
119.    LEVELS=10,  NCOUT=24, NLOUT=10,
120.   &END
121. ZIP 1C
```

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75   PAGE   1

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SOLIC ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75   PAGE 2

ZIP 410   0   0   0   0   0 OUTPUT CONTROL OPTIONS

NAM1 LIST

I/O CONTROL
IAIR   = -1
INPRIN = 1
IPRP   = 1   1   1
IPSM   = -2
IVP   = -1
ICOST   = 1
IPACK   = 0
KFIL12 = 0
MPAGE   = 6

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THIS AND THE FOLLOWING 10 PAGES
ARE THE "OUTPUT OF THE INPUT"
INCLUDING ALL INPUT PLUS
PRESTORED VALUES

v VIII-7

* * * * UNCLASSIFIED * * * *

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CCSM   FEB 75   PAGE 6

ZIF 7 4 1   0   0   0   0   0 READ BASIC VARIABLES

IC1= 2010000, ID2=   0, ID3= 0
TABLE NO. 2C10000   0 C74001   1

ROW	KVAR	.NAME* * *	NVAL	VALUE 1
1	1.	M-AREA	1	15.240
2	2.	T-AREA	1	7.2300
3	3.	W-ASP.R.	1	1.0000
4	4.	LT.PLC	1	118.00
5	5.	W/H WT	1	1000.0
6	6.	CONT.WT	1	195.00
7	7.	DIAMETER	1	28.000
8	8.	POO.T/W	1	10.000
9	9.	MAX THR	1	10000.
10	10.	ISP	1	285.00
11	11.	PCHAM	1	1500.0
12	12.	MIX R	1	1.0000
13	13.	DUMMY	1	0.0
14	14.	DUMMY	1	0.0
15	15.	DUMMY	1	0.0
16	16.	DUMMY	1	0.0
17	17.	WEIGHT	1	8000.0

INTEGER   TABLE TYPE   0
REAL   CONSTANTS   0.0   0.0   0.0   0.0   0.0   0.0

* * * * UNCLASSIFIED * * * *

```
 *    *    *    *    *    *    *    *        UNCLASSIFIED     *    *    *    *    *    *    *    *

      SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)  CGSM   FEB 75        PAGE  7

 &NAMCST
 QD= 20.00000    ,R= 1.0000000    ,IYEAR=    1974,NSCRC=    0,NSCOST=    1,KGTABL=    1,KGTYPE=    22,
 WTGUID= 350.00000   ,FC= 15.000000   ,BSP= 0.0    ,PPEAK= 250.00000   ,NDET=    0,KSTAB=    0,KAGATE=
        0,NCHAN=    0,KSGATE=    0,ICTYPE=    1,KGAIN=    0,KFUZE=    0
 &END

 *    *    *    *    *    *    *    *        UNCLASSIFIED     *    *    *    *    *    *    *    *
```

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75   PAGE 8

```
ZIF  9 3 0    0    0    0    0    0

&NAM3
WORTH1= 37.449997    ,NRMAX=
75.0C0000    ,    1000.0000    ,DWRMAX= -7.2999992    ,DWRMAX= -4.6999998    ,    25.000000    ,    -2.6999998    ,    40.000000    ,    50.00000C    ,    64.000000    .
6.6955998    ,    6.6999998    ,NWTWH=    3,PVNTWH= 500.00000    ,    1000.0000    ,    2000.0000    ,    5.000000    ,
0.0    ,    0.0    ,DWMTWH= -6.3999996    ,DWMTWH= -6.3999996    ,    17.599991    ,    C.0    ,
0.0    ,    0.0    ,NRCR=    ,    0,PVRCR= 0.0    ,    0.0    ,    0.0    ,
0.0    ,    0.0    ,    ,DWRCR= 0.0    ,    0.0    ,    0.0    ,
0.0    ,    0.0    ,    ,NRLL=    ,    0,PVRLL= 0.0    ,    0.0    ,
0.0    ,    0.0    ,    ,DWRLL= 0.0    ,    0,PVHCR= 0.0    ,
0.0    ,    0.0    ,    ,NHCR=    ,    0,PVHLL=
0.0    ,    0.0    ,    ,    0.0    ,    ,DWHCR= 0.0    ,DWHLL=
0.0    ,    0.0    ,    ,    0.0    ,    ,NHLL=    ,    0,PVHLL=
0.0    ,    0.0    ,    ,    0.0    ,    ,C.0    ,DWHLL=
0.0    ,    0.0    ,    ,    0.0    ,    ,    0.0    ,NVCR=    4,

PVVCR= 1.1999998    ,    2.5000000    ,    1.5000000    ,    4.3999996    ,    1.8999996    ,    5.3999996    ,    2.3999996    ,    0.0    ,    0.0    ,    ,NVLL=    ,DWVCR= 0.
PVVLL= C.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    ,NCEP=    ,DWVLL= 0.
PVCEP= 0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    ,NREL=    ,DWCEP= 0.
PVREL= 0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    ,NNO=    ,DWREL= 0.
PVNO= 0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    0.0    ,    ,    ,DWNO= 0.
0.99999979E-02,    0.0    ,    0.99999979E-02,    0.99999979E-02,    0.99999979E-02,    C.99999979E-02,    ,ZCEP=
0.99999979E-02,    C.99999979E-02,ZFORCE= 100.00000    ,ZGWT= 0.0    ,    1000.0000    ,    1000.0000    ,    1000.0000    ,
1000.0000    ,    1000.0000    ,    1000.0000    ,    1000.0000    ,ZREL= 0.9499999
&END
```

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SCLIC ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM FEB 75

ZIP 480   0   0   0   0   0

CONFIGURATION OPTIONS DATA LIST

NAMCNF NAMELIST

AIRFRAME		WING		TAIL		VERTICAL TAIL	
FACTOR	0.60	FSOVCW	0.0	FSOVCT	0.0	ARVT	1.0000
ILUG	0	GULT	10.00	GULT	10.00	FSOVVT	0.0
THETAC	0.1650	IPLANW	1	IPLANT	1	PANWVT	50.00
MOVAST	2.40	IWTS	3	IWTS	3	RXINVT	0.50
ZPCPT	1.	RL5	55.00	PANWHT	25.00	SLEVT	60.00
ZSKINI	0.10	RMDES	2.00	PANWT	20.00	STEVT	0.0
ZWSKIN	280.00	RXINW	0.50	RXINT	0.50	TRAVT	0.0500
		SLEW	60.00	SLET	45.00	TRVT	0.4000
		STEW	0.0	STET	0.0	VTALOC	0.68
		TRAW	0.0500	TRAT	0.0500	MOVAVT	6.00
		TRW	0.4000	TRT	0.2000		
		MOVAW	6.00	MOVAHT	6.00		
		WWINGI	105.00	MOVAT	6.00		
				WTI	50.00		

ALTITUDES AND MACH NO. USED IN COMPUTING AERO TABLES
NALT   2
ALTV   0.   10000.
NRM   9
RMV   0.40   0.80   0.90   1.00   1.20   1.40   1.60   2.00   3.00

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SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT (IPSM=-2)   CGSM   FEB 75

ZIP 5 8 0   0   C   C   C   O

BOOSTER DATA LIST (INTEGRAL CR EXTERNAL)

NAMBOO NAMELIST

ABM	0.0	EPI	10.0000	GAM	1.1800	RMCM	0.0	RNTM	0.1216E-03
AR	2.0000	ETAX	0.9000	GMAX	30.00	RMFSW	0.0	RNTMM	1.8340
AFAT	1.5C00	FBM	1.0000	PA	14.70	RMFM	0.0	SAW	0.0
AIT	0.0900	FCMM	1.0000	PBELL	1.00	RMIM	0.3000	SEM	0.10E 08
ASL	2.0000	FER	2.0000	PC	1000.	RNBWM	0.242E-05	TCASEF	900.0000
ASM	1.0000	FIT	0.1000	PCM	2000.	RNEC	0.680E-09	TL	0.1000
ASMM	0.0	FJ	C.9700	PHI	21.00	RNECC	0.2864E-05	TMIN	C.0700
CASEM	2.0000	FMPAH	C.5000	PSUB	0.0	RNEC1	0.80	TTH	45.0000
CSTAR	5000.00	FSL	0.0	RBOSS	0.5000	RNEC2	1.00	VRFH	0.0
DENI	0.1615	FSULX	1.4000	RHOP	0.0628	RNEC3	1.70		
CLFS	0.0	FSWM	0.0	RMASM	0.0	RNMM	5.00		
EAR	2.0000	FSYLX	1.2000	RMAM	0.0	RNRM	0.0		

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SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75

ZIP 5 8 1   0   0   0   0   0

EXTERNAL BOOSTER DATA LIST

NAMEXB NAMELIST

C1	1.10	CLEAR	2.50	RHOTHT	0.0500	TINAFT	0.25
C2	1.10	EL	2.00	RHOX	0.0200	TINS	0.25
C3	1.10	MTLRAM	2	TEMPC	90').	TMINC	0.06
C4	2.00	RHOENT	0.0400	TENT	0.20	TMIND	0.06
C5	2.00	RHOEXT	0.0400	TEXIT	0.20	TTHROT	0.20
C6	2.00	RHOIN	0.0650	TEXTER	0.0	WHARNS	25.00
				THETA	45.00	XSTAR	60.00

* * * * * * *

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75

ZIP 511 0   0   0   0   0

SOLID ROCKET SUSTAINER DATA LIST

NAMSR NAMELIST

AIAT	0.2500	PHINOZ	17.00	RHOS	0.0620
APAT	1.5000	REAH	2.00	SIGMTL	260000.
ETACF	0.9700	REFH	2.00	TIC	0.10
EXPBR	0.8200	RHOISS	0.C360	TRATIO	10.00
PBBLS	100.00	RHOMTL	0.2830	WMSOL	0.0
ETSISP	0.95C0				
CSTAR1	37.00				
CSTAR2	4946.00				

* * * * * * *

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SOLID ROCKET SSM TEST CASE – SINGLE CONCEPT(IIPSM=-2)   CGSM   FEB 75   PAGE 13

ZIP 615 0   1   0   0   0   0

TRAJECTORY PHASE CONTROL LIST

NCPHAZ   5   ALTI   50.   FARMAX   0.0
NDPHAZ   2   GAMMAI   20.0000 TPCMGN   0.0
                      TT4MAX   3900.
NLPHAZ   7   MOPT   0
NZLLRI   0   VELI   50.00
             XMACHI   0.0

NO.	ALPMAX	ALTF	ANZMAX	FVALUE	GAMMAF	ICONT	IPTYPE	ITERM	MHGEN	MODES	NAERO	XMACHF	ZPRINT	TPHASE	TTOTAL	SLCPE
1	15.0	500.	20.0	0.0	16.00	1	1	6	0	1	1	1.20	0.0	0.0	10000.0	0.
2	15.0	500.	20.0	-1.50	16.00	6	3	7	0	1	2	1.20	0.0	100.0	10000.0	0.
3	15.0	500.	20.0	0.0	0.0	14	3	1	0	0	2	1.20	0.0	100.0	10000.0	0.
4	15.0	500.	20.0	1.20	0.0	1	3	8	0	2	2	1.20	0.0	100.0	10000.0	0.
5	15.0	500.	20.0	5.00	0.0	13	3	4	0	0	2	1.20	0.0	0.0	10000.0	0.
6	15.0	0.	20.0	-1.00	0.0	6	3	1	0	-1	2	1.20	0.0	100.0	10000.0	0.
7	15.0	0.	20.0	0.0	-1.00	1	3	3	0	-1	2	1.20	0.0	0.0	10000.0	0.

DALPH	DALT	CCFN	DELMAX	DMCL	DMACH	DMIN	DSTART	DVCL	EREF	ERRFAC	GKG	GKV	GKVCRU	GTOPT	RANGEI	RTOL	TIMEI
0.009	2000.	0.10	60.0	10000.	0.050	0.0010	0.100	100.0	0.000500	5.0	1.00	0.0010	0.1	1.0	0.0	10.0	0.0

CONI 1	0.0	5.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONC 1	20.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONI 2	0.0	100.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONC 2	-3.00	-3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONI 4	0.0	100.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONC 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONI 6	0.0	100.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONC 6	-2.00	-2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONI 7	0.0	1000.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONC 7	-1.00	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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ZIP 1111   0   0   C   0   0

SUPER NAMELIST

TRAJECTORY DATA ITEMS		PROPULSION DATA ITEMS		CONFIGURATION DATA ITEMS	
ALTI	50.	BCANTA	0.0	ART	2.6700
FARMAX	0.0	DIAFR	0.50	BRAT	0.0
GAMMAI	20.00			FINE	3.0000
				FRBT	0.7500
MOPT	0			IART	1
NCPHAZ	5	DVMULT	1.20	IARW	1
NEPHAZ	2	DVTOL	30.00	IBTL	1
NLPHAZ	7	INWORL	0	ICNTRL	1
NZLLRI	0	ITHR	0	ISURFT	1
TPCMGN	0.0				
TT4MAX	3900.	KINLET	1	ISURFW	1
VELI	50.00	KPROP	13	ITN	2
XMACHI	0.0	MAXNIT	3	ITSECT	2
				IWSECT	2
		NZTEMP	0	KINLET	1
		VEOB	700.00	NW	1
		VL	50.00	WMISC	0.0
		XLRDY	0.0		
		ZXNB	2.		

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SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75

SEARCH FOR CONFIGURATION NO.   1

BASIC VARIABLES LIST

WING	TAIL	W.A.R	L.P/L	W.W/H	W.G/C	DIAM	B.T/W	F.PARAM	S.ISP	C.PRES	MIX.R	W.OR.L
15.24	7.23	1.00	118.0	1000.	195.	28.0	10.00	10000.	285.0	1500.	1.00	8000.

DUAL EXT BOOSTERS

PAYLOAD WEIGHT   1675.4
WING WEIGHT   161.5
TAIL WEIGHT   96.0

LOOP NO. 1 ON BOOSTER DELIVERED VELOCITY

IDEAL VELOCITY ASSIGNED AS   780.0 FPS

GO DESIGN AND SIZE PROPULSION SYSTEMS

PROPULSION STEP COMPLETE

GO COMPUTE AERO LIFT/DRAG DATA

AERO STEP COMPLETE

COMPUTE DELIVERED VELOCITY BY FLYING BOOST PHASE

DELIVERED VELOCITY MISSED BY   -103.1 FPS

THIS AND THE FOLLOWING PAGE ARE EXECUTIVE OUTPUT CONTROLLABLE THROUGH IPSM, IAIR, AND IVP IN THE NAM1 LIST.

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LCCF NO. 2 ON BOOSTER DELIVERED VELOCITY

IDEAL VELOCITY ASSIGNED AS   673.2 FPS

GO CESIGN AND SIZE PROPULSION SYSTEMS

PROPULSION STEP COMPLETE

GO COMPUTE AERO LIFT/CRAG DATA

AERO STEP COMPLETE

COMPUTE DELIVERED VELOCITY BY FLYING BOOST PHASE

CELIVERED VELOCITY MISSED BY   -0.2 FPS

LOCF NO. 2 ON BOOSTER DELIVERED VELOCITY

IDEAL VELOCITY ASSIGNED AS   673.2 FPS

GO CESIGN AND SIZE PROPULSION SYSTEMS

UNCLASSIFIED

SCLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM FEB 75   PAGE 18

BOOSTER DESIGN AND SIZING DATA

BOOSTER SIZING DETAILS		WEIGHTS		PERFORMANCE	INTERNAL BALLISTICS
PROPELLANT	341.66	THRLST	38834.10	CF 1.508	
INERTS	175.30	THRUST/WT	9.71	PERFCRMANCE	
TOTAL MOTOR	516.96	DELTA VI	672.775	CF VACUUM	1.640
PAYLOAC	3483.36	I TOTAL	80021.69	BURN TIME	2.061
LAUNCH WT	4000.11	ISP DEL	234.360	BURN RATE	1.118
BURN OUT WT	3658.66	ISP VAC	254.823	PORT/THROAT	1.500
DIMENSICNS		PRESSURES		MISCELLANEOUS	
CIAMETER	14.000	DESIGN	1200.00	MMF	0.6609
LT CYL	48.192	CHAMBER	1000.00	VOL LCADING	0.6882
LT FWC HEAC	3.500	AMBIENT	14.70	(I TOT)/WT	20.00
LT NOZZLE	23.208			NOZ CANT ANG	0.0
SKIRT EXTN	0.0				
TOTAL LT	74.900				

BREAKDOWN OF CHAMBER DESIGN   MATERIAL,200PSI STEEL

	FORWARD	CYLINDER	AFT	TOTAL
WEIGHTS				
STRUCTURE	5.172	54.930	4.171	64.272
INSULATION	3.134	33.784	2.259	39.176
BCSS	3.003	0.0	0.0	3.003
IGNITER	1.817			1.817
SKIRTS	0.0		2.280	2.280
CONSTANTS	0.0	0.0	0.0	0.0
TOTAL CHAMBER	13.126	88.714	8.709	110.548
PRCPELLANT	11.639	323.834	5.975	341.659
NOZZLE WEIGHT				64.752
TOTAL WEIGHT	24.764	412.548	14.684	516.960

THICKNESS	FORWARD	CYLINDER	AFT
INSULATION			
AVG	0.10000	C.10000	0.09000
MAX	0.10000		0.08000
CASE	0.09157	0.09157	0.09157

ULTIMATE CASE STRENGTH 129421. YIELD CASE STRENGTH 91729.
THE MINIMUM ALLOWABLE CASE THICKNESS WAS 0.07000

NOZZLE

NOZZLE BOSS	THROAT STRUCTURE	EXIT STRUCTURE	INSERT RETAINER	THROAT ASSEMBLY	EXIT CONE INSULATN	TOTAL WEIGHT	TOTAL LENGTH
2.09387	19.06805	2.4396C	0.0	34.12827	1.02263	64.75240	23.20778

BELL	HALF ANG	EPI	ENT RATIO	THROAT AREA
100.C0000	20.99998	9.23449	2.00000	25.75104

SCLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IIPSM=-2)   CCSM   FEB 75

PINTLE NOZZLE SCLID ROCKET

COMPONENT	WEIGHT-LB.	LENGTH-IN.
FORWARD SKIRT	30.401	7.000
FORWARD HEAD	64.390	7.000
CYLINDER	528.075	113.424
AFT HEAD	92.344	6.187
NOZZLE(TOTAL)	61.593	10.231
NOZZLE(EXTERNAL)		10.231
AFT SKIRT	64.070	14.752
MISCELLANEOUS	0.0	

TOTAL MOTOR WEIGHT= 5033.598 LB.

TOTAL INERT WEIGHT= 753.352 LB.

TOTAL PROP. WEIGHT= 4280.246 LB.

TOTAL MOTOR LENGTH= 136.842 IN.

PROP. WT. FRACTION= 0.85

MISSILE WEIGHT = 6966.484

THRUST TO WEIGHT = 1.44

MISSILE MASS RATIO= 0.61

PERFORMANCE PARAMETERS(COMPOSITE HTPB)

MAXIMUM THRUST= 1CCCC.000 LBF

MINIMUM THRUST= 1000.000 LBF

ISP AT MAX THR= 285.000 SEC

ISP AT MIN THR= 267.240 SEC

PC AT MAX THR= 1500.000 PSIA

PC AT MIN THR= 96.377 PSIA

THROAT AREA AT
MAX THRUST   =   3.910 SQ. IN.

THROAT AREA AT
MIN THRUST   =   6.366 SQ. IN.

EXIT CIA.   =   6.661 IN.

EXP. RATIO AT
MAX THRUST   =   8.91

EXP. RATIO AT
MIN THRUST   =   5.47

TOTAL IMPULSE
AT MAX THRUST =1158876.00 LB-SEC

TOTAL IMPULSE
AT MIN THRUST =1086657.00 LB-SEC

BURN TIME AT
MAX THRUST   =115.89 SEC

BURN TIME AT
MIN THRUST   = 1086.66 SEC

SUSTAINER DESIGN AND SIZING DATA

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* * * * * * * UNCLASSIFIED PAGE 20

SCLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM-2) CGSM FEB 75

PROPULSION STEP COMPLETE

GC COMPUTE AERO LIFT/DRAG DATA

* * * * * * * UNCLASSIFIED

ALT	MACH	CDO-SUST	CDO-BOOST	CLA
c.				
	0.40	0.159	0.352	0.246
	0.80	0.143	0.413	0.261
	0.90	0.143	0.473	0.268
	1.00	0.401	0.833	0.292
	1.20	0.549	1.085	0.306
	1.40	0.448	0.951	0.314
	1.60	0.395	0.866	0.293
	2.00	0.336	0.745	0.264
	3.00	0.247	0.577	0.217

* * * * * * * * * UNCLASSIFIED * * * * * * * * *

AERODYNAMICS DATA TABLES
(SEE ALSO NEXT PAGE)

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SCLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CCSM   FEB 75

ALT	MACH	CDO-SUST	CDO-BOOST	CLA
10000.	0.40	0.164	0.358	0.246
	0.80	0.148	0.418	0.261
	0.90	0.147	0.479	0.268
	1.00	0.405	0.838	0.292
	1.20	0.553	1.090	0.306
	1.40	0.452	0.955	0.314
	1.60	0.398	0.870	0.293
	2.00	0.339	0.749	0.264
	3.00	0.249	0.580	0.217

AERC STEP COMPLETE

COMPUTE DELIVERED VELOCITY BY FLYING BOOST PHASE

*   *   *   *   *   *   UNCLASSIFIED   *   *   *   *   *   *

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75   PAGE 23

DELIVERED VELOCITY CONVERGED - MISS IS   -0.2 FPS

    GO FLY COMPLETE TRAJECTORY NO.   1

*   *   *   *   *   *   UNCLASSIFIED   *   *   *   *   *   *

THE FOLLOWING 6 PAGES INCLUDE
A TIME HISTORY PRINT OF THE
TRAJECTORY PARAMETERS

SCLIC ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM FEB 75   PAGE 24

TIME SEC	GAMMA DEG	SPEED FT/SEC	ALTITUDE FT	RANGE N MI	WEIGHT LBM	THRUST LBF	NX G	NZ G	ALPHA DEG	THETA DEG	LIFT LBF	DRAG LBF	MACH	STEPS GOOD	STEPS BAD	NERR
0.0	20.00	50.0	50.0	0.0	8000.0	77473.0	9.648	0.831	4.91	24.91	16.4	5.9	0.04	0	0	0
0.10	19.60	80.0	52.2	0.00	7966.8	77473.6	9.693	0.768	4.50	24.10	38.5	14.5	0.07	1	0	2
0.31	18.78	142.4	59.7	0.00	7898.6	77475.5	9.783	0.638	3.65	22.43	99.0	42.5	0.13	2	0	2
1.13	15.48	398.6	124.0	0.04	7625.4	77491.7	10.125	-0.098	0.48	15.96	101.2	284.2	0.36	3	0	2
2.06	11.75	700.2	243.0	0.12	7316.7	77521.5	10.452	-0.541	-1.95	9.80	-1321.0	1001.6	0.63	4	1	2
2.06	11.75	700.2	243.0	0.12	6986.1	9492.4	1.293	-0.342	-3.00	8.75	-1885.5	470.4	0.63	4	1	2
2.16	11.41	703.7	257.0	0.13	6962.4	9492.7	1.293	-0.345	-3.00	8.41	-1904.6	474.7	0.63	5	1	6
2.56	10.02	717.9	309.9	0.18	6947.6	9493.7	1.294	-0.357	-3.00	7.02	-1983.2	492.3	0.64	6	1	2
3.63	6.39	757.4	421.7	0.31	6908.2	9495.7	1.294	-0.392	-3.00	3.39	-2211.5	542.8	0.68	7	1	2
4.28	4.22	782.5	467.9	0.35	6884.1	9496.6	1.294	-0.416	-3.00	1.22	-2365.3	576.3	0.70	8	1	2
4.67	2.92	798.0	487.1	0.44	6869.7	9496.9	1.294	-0.431	-3.00	-0.08	-2463.4	597.5	0.72	9	1	2
4.82	2.41	804.2	492.9	0.46	6864.0	9497.0	1.293	-0.437	-3.00	-0.59	-2503.5	606.1	0.72	10	1	7
4.82	2.41	804.2	492.9	0.46	6864.0	9497.1	1.067	-1.499	-10.30	-7.89	-8593.8	2019.7	0.72	10	1	7
4.92	1.84	807.5	495.9	0.47	6860.3	9497.1	1.069	-1.499	-10.22	-8.37	-8599.3	2011.9	0.72	11	1	2
5.18	0.37	816.3	499.9	0.51	6850.7	9497.1	1.074	-1.499	-10.01	-9.64	-8615.0	1992.7	0.73	12	1	2
5.25	0.00	818.6	500.1	0.52	6848.2	9497.1	1.076	-1.499	-9.95	-9.95	-8621.0	1988.2	0.73	13	1	2
5.25	0.00	818.6	500.1	0.52	6848.2	9497.1	1.209	0.999	6.63	6.63	5743.4	1155.1	0.73	13	1	2
5.35	0.00	822.5	500.1	0.53	6844.5	9497.1	1.210	0.999	6.57	6.57	5749.5	1154.6	0.74	14	1	2
5.62	0.00	833.0	500.1	0.57	6834.6	9497.1	1.212	0.999	6.42	6.42	5765.1	1151.6	0.75	15	1	2
6.70	-0.00	875.2	500.1	0.72	6794.6	9497.1	1.222	0.999	5.84	5.84	5820.8	1145.7	0.79	16	1	2
11.01	0.00	1045.0	500.1	1.40	6635.0	9497.1	1.168	0.998	3.94	3.94	5970.6	1723.4	0.94	17	1	3
13.22	0.00	1121.8	500.1	1.79	6553.5	9497.1	1.004	0.998	3.26	3.26	6001.4	2900.4	1.01	18	3	3
15.05	0.00	1179.1	500.1	2.14	6485.8	9497.1	0.939	0.998	2.91	2.91	5990.4	3396.2	1.06	19	3	3
16.82	0.00	1230.8	500.1	2.46	6420.1	9497.1	0.870	0.998	2.63	2.63	5969.4	3904.2	1.10	20	3	3
21.06	0.00	1337.4	500.1	3.36	6265.4	9497.1	0.694	0.997	2.15	2.15	5889.9	5143.2	1.20	21	4	3
21.06	0.0	1337.4	500.1	3.36	6261.4	5158.9	-0.000	0.997	2.21	2.21	6047.6	5155.2	1.20	21	4	7
21.16	0.0	1337.4	500.1	3.41	6261.3	5158.8	-0.000	0.997	2.21	2.21	6045.5	5154.1	1.20	22	4	7
21.56	0.0	1337.4	500.1	3.50	6252.6	5158.1	-0.000	0.997	2.21	2.21	6037.4	5151.9	1.20	23	4	7
23.16	0.0	1337.4	500.1	3.85	6218.9	5155.6	-0.000	0.997	2.19	2.19	6004.7	5142.0	1.20	24	4	7
29.56	0.0	1337.4	500.1	5.26	6083.4	5145.6	-0.000	0.997	2.15	2.15	5874.2	5120.9	1.20	25	4	7
43.78	0.0	1337.4	500.1	8.39	5783.2	5124.1	-0.000	0.950	2.04	2.04	5585.1	5113.2	1.20	26	4	6
43.88	-0.27	1334.8	499.8	8.41	5782.8	497.1	-0.798	-0.946	-2.00	-2.00	-5475.8	5078.5	1.20	27	4	2
44.15	-1.00	1328.1	495.8	8.47	5781.7	497.1	-0.792	-0.935	-2.00	-2.27	-5452.2	4987.4	1.19	28	4	2
44.15	-1.00	1328.1	495.8	8.47	5781.7	497.1	-0.777	-0.997	-2.00	-3.00	-5390.2	5013.1	1.19	28	4	2
44.25	-1.00	1325.6	493.4	8.49	5781.3	497.0	-0.776	0.997	2.14	1.13	5747.2	4982.2	1.19	29	4	6
44.65	-1.00	1316.0	484.2	8.58	5779.7	496.9	-0.755	0.997	2.18	1.18	5745.0	4862.0	1.18	30	4	3
46.25	-1.00	1280.0	448.0	8.92	5773.4	496.2	-0.682	0.997	2.31	1.31	5738.3	4431.3	1.15	31	4	3
52.65	-1.00	1165.5	311.8	10.21	5748.2	493.7	-0.481	0.998	2.83	1.83	5713.3	3258.6	1.05	32	4	3
56.21	-1.00	1117.1	240.9	10.87	5734.2	492.4	-0.410	0.999	3.10	2.10	5701.8	2841.2	1.00	33	5	2
58.81	-1.00	1088.0	191.0	11.35	5724.0	491.5	-0.324	0.999	3.32	2.32	5688.7	2346.1	0.98	34	5	3
61.06	-1.00	1068.0	148.7	11.74	5715.1	490.7	-0.268	0.998	3.49	2.49	5676.5	2020.5	0.96	35	5	2
64.04	-1.00	1046.7	93.5	12.26	5703.3	489.7	-0.212	0.999	3.68	2.68	5664.2	1699.0	0.94	36	5	2
67.44	-1.00	1028.1	32.2	12.84	5690.0	488.6	-0.167	0.999	3.85	2.85	5653.1	1436.6	0.92	37	6	6
69.24	-1.00	1020.0	0.0	13.15	5682.9	488.0	-0.148	0.998	3.93	2.93	5640.8	1327.1	0.91	38	6	2

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CESM   FEB 75

TIME SEC	G-DOT DEG/SEC	V-DOT FT/SEC	H-DOT FT/SEC	R-DOT FT/SEC	W-DOT LBM/SEC	CFNREQ	CFN	SFC LBM/HR/LBF	TT4 DEG R	ISP SEC	V-IDEAL FT/SEC	NMAP	DYN PRESS LBS/FT2
0.0	-4.000	299.4	17.1	47.0	-331.4	0.0	*********	15.3997	0.0	233.8	0.0	0	2.97
0.10	-4.000	301.1	26.8	75.4	-331.4	0.0	*********	15.3996	0.0	233.8	34.0	0	7.60
0.31	-4.000	304.4	45.8	134.8	-331.4	0.0	753.14185	15.3992	0.0	233.8	104.6	0	24.06
1.13	-4.003	317.2	106.4	384.1	-331.4	0.0	96.31850	15.3960	0.0	233.8	393.1	0	188.15
2.06	-4.000	329.7	142.6	685.5	-331.4	0.0	31.33824	15.3901	0.0	233.9	732.0	0	578.50
2.06	-3.476	35.1	142.6	685.5	-37.0	*********	3.83734	14.0264	0.0	256.7	732.0	0	578.50
2.16	-3.470	35.3	139.1	689.8	-37.0	*********	3.80077	14.0261	0.0	256.7	736.6	0	584.08
2.56	-3.443	36.0	124.9	707.0	-37.0	*********	3.65738	14.0246	0.0	256.7	755.1	0	607.04
3.63	-3.371	38.1	84.3	752.7	-37.0	*********	3.29774	14.0216	0.0	256.7	804.6	0	673.39
4.28	-3.327	39.3	57.5	780.4	-37.0	*********	3.09386	14.0204	0.0	256.8	834.9	0	717.83
4.61	-3.300	40.0	40.7	796.9	-37.0	*********	2.97680	14.0198	0.0	256.8	853.2	0	746.09
4.82	-3.290	40.3	33.9	803.5	-37.0	*********	2.93153	14.0197	0.0	256.8	860.5	0	757.62
4.82	-5.725	33.0	33.9	803.5	-37.0	*********	2.93153	14.0197	0.0	256.8	860.5	0	757.62
4.92	-5.701	33.4	26.0	807.1	-37.0	4.14128	2.90777	14.0196	0.0	256.8	865.1	0	763.81
5.18	-5.640	34.4	5.3	816.3	-37.0	3.93752	2.84587	14.0195	0.0	256.8	877.3	0	780.43
5.25	-5.625	34.6	0.0	818.5	-37.0	3.88658	2.83015	14.0195	0.0	256.8	880.4	0	784.77
5.25	-0.000	38.9	0.0	818.5	-37.0	*********	2.83015	14.0195	0.0	256.8	880.4	0	784.77
5.35	-0.000	38.9	0.0	822.4	-37.0	*********	2.80343	14.0195	0.0	256.8	885.1	0	792.24
5.62	-0.000	39.0	0.0	832.9	-37.0	*********	2.73311	14.0195	0.0	256.8	897.8	0	812.63
6.70	-0.000	39.3	-0.0	875.2	-37.0	*********	2.47550	14.0195	0.0	256.8	948.8	0	897.19
11.01	-0.000	37.6	0.0	1045.0	-37.0	*********	1.73650	14.0195	0.0	256.8	1155.6	0	1279.01
13.22	-0.000	32.3	0.0	1121.8	-37.0	*********	1.50684	14.0195	0.0	256.8	1263.1	0	1473.95
15.05	-0.000	30.2	0.0	1179.0	-37.0	*********	1.36410	14.0195	0.0	256.8	1353.4	0	1628.19
16.82	-0.000	28.0	0.0	1230.8	-37.0	*********	1.25185	14.0195	0.0	256.8	1442.1	0	1774.18
21.06	-0.000	22.3	0.0	1337.4	-37.0	*********	1.06020	14.0195	0.0	256.8	1657.0	0	2094.88
21.06	0.0	-0.0	0.0	1337.4	-21.2	0.57591	0.57591	14.7969	0.0	243.3	1657.0	0	2094.88
21.16	0.0	-0.0	0.0	1337.4	-21.2	0.57590	0.57590	14.7970	0.0	243.3	1659.9	0	2094.88
21.56	0.0	-0.0	0.0	1337.4	-21.2	0.57583	0.57582	14.7972	0.0	243.3	1671.5	0	2094.88
23.16	0.0	-0.0	0.0	1337.4	-21.2	0.57554	0.57554	14.7980	0.0	243.3	1718.2	0	2094.88
29.56	0.0	-0.0	0.0	1337.4	-21.2	0.57443	0.57443	14.8014	0.0	243.2	1907.5	0	2094.87
43.78	0.0	-0.0	0.0	1337.4	-21.1	0.57203	0.57203	14.8086	0.0	243.1	2342.2	0	2094.87
43.78	-2.684	-25.7	0.0	1337.4	-3.9	*********	0.05550	28.5228	0.0	126.2	2342.2	0	2094.87
43.88	-2.683	-25.3	-6.3	1334.8	-3.9	*********	0.05571	28.5232	0.0	126.2	2342.8	0	2086.91
44.15	-2.682	-24.4	-23.2	1327.8	-3.9	*********	0.05627	28.5274	0.0	126.2	2344.3	0	2065.98
44.15	0.000	-24.6	-23.2	1327.8	-3.9	*********	0.05627	28.5274	0.0	126.2	2344.3	0	2065.98
44.25	0.000	-24.4	-23.1	1325.4	-3.9	*********	0.05647	28.5297	0.0	126.2	2344.8	0	2058.51
44.65	0.000	-23.7	-23.0	1315.8	-3.9	*********	0.05726	28.5394	0.0	126.1	2347.1	0	2029.27
46.25	0.000	-21.4	-22.3	1279.7	-3.9	*********	0.06038	28.5774	0.0	126.0	2356.0	0	1921.70
52.65	0.001	-14.9	-20.4	1165.7	-3.9	*********	0.07212	28.7217	0.0	125.3	2391.7	0	1600.87
56.21	0.002	-12.6	-19.5	1116.9	-3.9	*********	0.07819	28.7976	0.0	125.0	2411.7	0	1472.71
58.81	0.001	-9.9	-19.0	1087.8	-3.9	*********	0.08215	28.8515	0.0	124.8	2426.3	0	1349.67
61.06	0.001	-8.1	-18.6	1067.8	-3.9	*********	0.08503	28.8972	0.0	124.6	2438.9	0	1298.57
64.04	0.001	-6.3	-18.3	1046.5	-3.9	*********	0.08819	28.9573	0.0	124.3	2455.8	0	1255.03
67.44	0.002	-4.8	-18.0	1027.9	-3.9	*********	0.09104	29.0244	0.0	124.0	2474.9	0	1236.53
69.24	0.000	-4.2	-17.8	1019.8	-3.9	*********	0.09229	29.0598	0.0	123.9	2485.1	0	

D RANGE=   31.30, DRDW=   0.01044, W-WEMPTY=   2997.07, RNCI=   36.30NMI

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75   PAGE 26

TIME SEC	GAMMA DEG	SPEED FT/SEC	ALTITUDE FT	RANGE N MI	WEIGHT LBM	THRUST LBF	NX G	NZ G	ALPHA DEG	THETA DEG	LIFT LBF	DRAG LBF	MACH	STEPS GOOD	STEPS BAD	NERR
21.06	0.0	1337.4	500.1	3.39	6263.4	5158.9	-0.000	0.997	2.21	2.21	6047.6	5155.2	1.20	38	6	2
21.16	0.0	1337.4	500.1	3.41	6261.3	5158.8	-0.000	0.997	2.21	2.21	6045.5	5155.1	1.20	39	6	7
21.56	0.0	1337.4	500.1	3.50	6252.8	5158.1	-0.000	0.997	2.21	2.21	6037.4	5154.4	1.20	40	6	7
23.16	0.0	1337.4	500.1	3.85	6218.9	5155.6	-0.000	0.997	2.19	2.19	6004.7	5151.9	1.20	41	6	7
29.56	0.0	1337.4	500.1	5.26	6083.4	5145.6	-0.000	0.997	2.15	2.15	5874.2	5142.0	1.20	42	6	7
55.16	0.0	1337.4	500.1	10.90	5543.6	5107.8	-0.000	0.997	1.96	1.96	5354.2	5104.8	1.20	43	6	7
83.66	0.0	1337.4	500.1	17.17	4946.5	5070.0	-0.000	0.997	1.75	1.75	4778.7	5067.6	1.20	44	6	7
102.43	0.0	1337.4	500.1	21.30	4555.4	5047.5	-0.000	0.997	1.61	1.61	4401.5	5045.5	1.20	45	7	7
117.71	0.0	1337.4	500.1	24.66	4238.1	5030.7	0.0	0.997	1.50	1.50	4095.3	5029.0	1.20	46	7	7
133.17	0.0	1337.4	500.1	28.06	3918.0	5014.9	0.000	0.997	1.38	1.38	3786.3	5013.4	1.20	47	7	7
148.74	0.0	1337.4	500.1	31.45	3596.4	5000.2	0.0	0.997	1.27	1.27	3475.9	4999.1	1.20	48	7	7
162.87	0.0	1337.4	500.1	34.60	3305.1	4988.1	-0.000	0.997	1.17	1.17	3194.5	4987.1	1.20	49	7	7
175.35	0.0	1337.4	500.1	37.35	3048.6	4978.3	0.0	0.997	1.08	1.08	2946.8	4977.4	1.20	50	7	7
185.97	0.0	1337.4	500.1	39.69	2830.4	4970.5	-0.000	0.997	1.00	1.00	2736.1	4969.8	1.20	51	7	7
185.97	0.0	1337.4	500.1	39.69	2830.1	497.1	-1.631	-1.941	-2.00	-2.00	-5475.8	5113.2	1.20	51	7	7
186.07	-0.40	1332.2	499.6	39.71	2830.0	497.1	-1.606	-1.924	-2.00	-2.40	-5427.8	5042.7	1.20	52	7	7
186.22	-1.00	1324.7	497.2	39.74	2829.5	497.1	-1.571	-1.900	-2.00	-3.00	-5359.2	4942.3	1.19	53	7	2
186.22	-1.00	1324.7	497.2	39.74	2829.5	497.1	-1.523	1.001	1.05	0.05	2824.1	4807.1	1.19	53	7	2
186.32	-1.00	1319.9	494.9	39.76	2829.1	497.1	-1.502	1.001	1.06	0.06	2822.6	4745.4	1.18	54	7	3
186.72	-1.00	1301.3	485.8	39.85	2827.5	496.9	-1.420	1.000	1.09	0.10	2817.7	4511.9	1.17	55	7	2
188.32	-1.00	1236.3	450.5	40.18	2821.2	496.2	-1.155	0.998	1.22	0.23	2806.3	3755.5	1.11	56	7	3
190.92	-1.00	1154.0	396.5	40.69	2810.9	495.3	-0.865	0.996	1.42	0.42	2787.6	2926.7	1.04	57	8	3
193.41	-1.00	1094.5	347.8	41.15	2801.1	494.4	-0.614	0.997	1.60	0.60	2778.8	2215.4	0.98	58	9	3
194.77	-1.00	1072.0	322.1	41.40	2795.8	493.9	-0.476	0.998	1.70	0.70	2775.0	1823.9	0.96	59	9	3
196.24	-1.00	1053.0	294.9	41.65	2790.0	493.4	-0.368	0.998	1.78	0.78	2769.3	1520.8	0.94	60	9	3
200.02	-1.00	1021.6	226.6	42.30	2775.1	492.1	-0.204	0.998	1.92	0.92	2753.0	1059.1	0.92	61	9	3
203.63	-1.00	1005.0	162.7	42.90	2760.9	491.0	-0.124	0.997	1.99	1.00	2736.6	833.6	0.90	62	10	2
206.95	-1.00	994.1	104.9	43.44	2747.8	489.9	-0.117	0.996	2.03	1.03	2720.4	811.1	0.89	63	10	2
209.21	-1.00	986.9	65.8	43.81	2738.9	489.2	-0.115	0.997	2.06	1.06	2714.4	802.8	0.88	64	10	2
211.17	-1.00	980.9	32.1	44.13	2731.2	488.6	-0.113	0.998	2.08	1.08	2708.3	795.7	0.88	65	10	2
213.05	-1.00	975.2	0.0	44.43	2723.8	488.0	-0.111	0.998	2.10	1.10	2701.5	789.1	0.87	66	10	2

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM FEB 75   PAGE 27

TIME SEC	G-DOT DEG/SEC	V-DOT FT/SEC	H-DOT FT/SEC	R-DOT FT/SEC	W-DOT LBM/SEC	CFNREQ	CFN	SFC LBM/HR/LBF	TT4 DEG R	ISP SEC	V-IDEAL FT/SEC	NMAP	DYN PRESS LBS/FT2
21.06	0.0	-0.0	0.0	1337.4	-21.2	0.57591	0.57591	14.7969	0.0	243.3	1657.0	0	2094.88
21.16	0.0	-0.0	0.0	1337.4	-21.2	0.57590	0.57590	14.7970	0.0	243.3	1659.9	0	2094.88
21.56	0.0	-0.0	0.0	1337.4	-21.2	0.57583	0.57582	14.7972	0.0	243.3	1671.5	0	2094.88
23.16	0.0	-0.0	0.0	1337.4	-21.2	0.57554	0.57554	14.7980	0.0	243.3	1718.2	0	2094.88
29.56	0.0	-0.0	0.0	1337.4	-21.2	0.57443	0.57443	14.8014	0.0	243.2	1907.5	0	2094.87
55.16	0.0	-0.0	0.0	1337.4	-21.0	0.57020	0.57020	14.8141	0.0	243.0	2705.6	0	2094.87
83.66	0.0	-0.0	0.0	1337.4	-20.9	0.56598	0.56598	14.8269	0.0	242.8	3684.2	0	2094.87
102.43	0.0	-0.0	0.0	1337.4	-20.8	0.56348	0.56348	14.8346	0.0	242.7	4391.4	0	2094.86
117.71	0.0	-0.0	0.0	1337.4	-20.7	0.56160	0.56160	14.8404	0.0	242.6	5011.3	0	2094.86
133.17	0.0	-0.0	0.0	1337.4	-20.7	0.55984	0.55984	14.8459	0.0	242.5	5685.6	0	2094.86
148.74	0.0	-0.0	0.0	1337.4	-20.6	0.55821	0.55821	14.8510	0.0	242.4	6420.7	0	2094.86
162.87	0.0	-0.0	0.0	1337.4	-20.6	0.55685	0.55685	14.8553	0.0	242.3	7145.8	0	2094.86
175.35	0.0	-0.0	0.0	1337.4	-20.5	0.55575	0.55575	14.8587	0.0	242.3	7839.1	0	2094.86
185.97	0.0	-0.0	0.0	1337.4	-20.5	0.55488	0.55488	14.8615	0.0	242.2	8476.3	0	2094.86
185.97	-4.050	-52.5	0.0	1337.4	-3.9*********	*********	0.05550	28.5228	0.0	126.2	8476.3	0	2094.86
186.07	-4.042	-51.5	-9.4	1332.1	-3.9*********	*********	0.05593	28.5233	0.0	126.2	8477.4	0	2078.65
186.22	-4.032	-50.0	-23.1	1324.5	-3.9*********	*********	0.05656	28.5258	0.0	126.2	8479.1	0	2055.46
186.22	0.006	-48.4	-23.1	1324.5	-3.9*********	*********	0.05656	28.5258	0.0	126.2	8479.1	0	2055.46
186.32	0.005	-47.8	-23.1	1319.7	-3.9*********	*********	0.05696	28.5283	0.0	126.2	8480.2	0	2040.71
186.72	0.004	-45.1	-22.7	1301.1	-3.9*********	*********	0.05856	28.5379	0.0	126.1	8484.8	0	1984.23
188.32	0.001	-36.6	-21.5	1236.1	-3.9*********	*********	0.06473	28.5748	0.0	126.0	8503.0	0	1792.76
190.92	-0.003	-27.3	-20.1	1153.8	-3.9*********	*********	0.07403	28.6318	0.0	125.7	8532.8	0	1564.53
193.41	-0.002	-19.2	-19.1	1094.7	-3.9*********	*********	0.08197	28.6833	0.0	125.5	8561.3	0	1410.42
194.77	-0.001	-14.7	-18.7	1071.8	-3.9*********	*********	0.08537	28.7108	0.0	125.4	8576.9	0	1352.96
196.24	-0.000	-11.3	-18.4	1052.8	-3.9*********	*********	0.08832	28.7398	0.0	125.3	8593.9	0	1306.50
200.02	-0.001	-6.0	-17.8	1021.4	-3.9*********	*********	0.09340	28.8129	0.0	124.9	8637.5	0	1232.19
203.63	-0.002	-3.4	-17.5	1004.8	-3.9*********	*********	0.09610	28.8820	0.0	124.6	8679.5	0	1194.73
206.95	-0.004	-3.2	-17.3	994.0	-3.9*********	*********	0.09784	28.9449	0.0	124.4	8718.3	0	1170.95
209.21	-0.002	-3.1	-17.2	986.8	-3.9*********	*********	0.09901	28.9876	0.0	124.2	8744.8	0	1155.45
211.17	-0.001	-3.1	-17.1	980.7	-3.9*********	*********	0.10001	29.0245	0.0	124.0	8767.9	0	1142.38
213.05	-0.000	-3.0	-17.0	975.0	-3.9*********	*********	0.10097	29.0598	0.0	123.9	8790.1	0	1130.22

RANEE= 0.4I, DRDW= 0.01073, W-WEMPTY= 37.95, RNGI=   36.70NMI

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM FEB 75   PAGE 28

TIME SEC	GAMMA DEG	SPEED FT/SEC	ALTITUDE FT	RANGE N MI	WEIGHT LBM	THRUST LBF	NX G	NZ G	ALPHA CEG	THETA DEG	LIFT LBF	DRAG LBF	MACH	STEPS GOOD	STEPS BAD	NERR
21.06	0.0	1337.4	500.1	3.39	6263.4	5158.9	-0.000	0.997	2.21	2.21	6047.6	5155.2	1.20	66	10	2
21.16	0.0	1337.4	500.1	3.41	6261.3	5158.8	-0.000	0.997	2.21	2.21	6045.5	5155.1	1.20	67	10	7
21.56	0.0	1337.4	500.1	3.50	6252.8	5158.1	-0.000	0.997	2.21	2.21	6037.4	5154.4	1.20	68	10	7
23.16	0.0	1337.4	500.1	3.85	6218.9	5155.6	-0.000	0.997	2.19	2.19	6004.7	5151.9	1.20	69	10	7
29.56	0.0	1337.4	500.1	5.26	6083.4	5145.6	-0.000	0.997	2.15	2.15	5874.2	5142.0	1.20	70	10	7
55.16	0.0	1337.4	500.1	10.90	5543.6	5107.8	-0.000	0.997	1.96	1.96	5354.2	5104.8	1.20	71	10	7
83.66	0.0	1337.4	500.1	17.17	4946.5	5070.0	-0.000	0.997	1.75	1.75	4778.7	5067.6	1.20	72	11	7
102.43	0.0	1337.4	500.1	21.30	4555.4	5047.5	-0.000	0.997	1.61	1.61	4401.5	5045.5	1.20	73	11	7
117.71	0.0	1337.4	500.1	24.66	4238.1	5030.7	0.0	0.997	1.50	1.50	4095.3	5029.0	1.20	74	11	7
133.17	0.0	1337.4	500.1	28.06	3918.0	5014.9	0.000	0.997	1.38	1.38	3786.3	5013.4	1.20	75	11	7
148.74	0.0	1337.4	500.1	31.49	3596.4	5000.3	0.0	0.997	1.27	1.27	3475.9	4999.1	1.20	76	11	7
162.87	0.0	1337.4	500.1	34.60	3305.1	4988.1	-0.000	0.997	1.17	1.17	3194.5	4987.1	1.20	77	11	7
175.35	0.0	1337.4	500.1	37.35	3048.6	4978.3	0.0	0.997	1.08	1.08	2946.8	4977.4	1.20	78	11	7
186.75	0.0	1337.4	500.1	39.86	2814.3	4970.0	0.0	0.977	0.99	0.99	2720.5	4969.2	1.20	79	11	7
187.82	0.0	1337.4	500.1	40.09	2792.5	4969.2	0.0	0.997	0.99	0.99	2699.4	4968.5	1.20	80	11	7
187.82	0.0	1337.4	500.1	40.05	2792.5	497.1	-1.653	-1.967	-2.00	-2.00	-5475.8	5113.2	1.20	80	11	7
187.92	-0.41	1332.1	499.6	40.12	2792.1	497.1	-1.628	-1.950	-2.00	-2.41	-5427.1	5041.7	1.20	81	11	2
188.06	-1.00	1324.6	497.2	40.15	2791.5	497.1	-1.592	-1.926	-2.00	-3.00	-5358.6	4941.5	1.19	82	11	2
188.06	-1.00	1324.6	497.2	40.15	2791.5	497.1	-1.543	1.001	1.04	0.04	2786.3	4805.0	1.19	82	11	2
188.16	-1.00	1319.8	494.9	40.17	2791.1	497.1	-1.521	1.001	1.05	0.05	2784.9	4742.4	1.18	83	11	3
188.58	-1.00	1301.0	485.8	40.26	2789.6	496.9	-1.437	1.000	1.08	0.08	2780.0	4506.1	1.17	84	11	2
190.16	-1.00	1235.2	450.5	40.59	2783.3	496.2	-1.166	0.999	1.21	0.21	2768.5	3742.1	1.11	85	11	3
192.65	-1.00	1154.4	398.1	41.09	2773.3	495.3	-0.877	0.996	1.40	0.40	2750.0	2928.0	1.04	86	12	3
195.08	-1.00	1096.7	351.4	41.53	2763.9	494.4	-0.633	0.997	1.57	0.57	2742.2	2244.6	0.98	87	13	3
196.42	-1.00	1073.4	326.1	41.77	2758.6	494.0	-0.490	0.998	1.67	0.67	2738.3	1845.5	0.96	88	13	3
197.82	-1.00	1054.6	300.0	42.01	2753.1	493.5	-0.382	0.998	1.75	0.75	2732.8	1543.9	0.95	89	13	3
201.44	-1.00	1023.2	234.5	42.63	2738.8	492.3	-0.214	0.998	1.89	0.89	2717.2	1078.6	0.92	90	13	3
205.25	-1.00	1005.1	167.1	43.26	2723.8	491.0	-0.125	0.997	1.97	0.97	2699.9	832.5	0.90	91	14	2
209.06	-0.99	992.5	100.7	43.89	2708.8	489.8	-0.117	0.995	2.00	1.01	2677.4	806.2	0.89	92	14	2
211.22	-1.00	985.7	63.5	44.24	2700.3	489.1	-0.115	0.997	2.03	1.03	2674.7	798.5	0.88	93	14	2
212.84	-1.00	980.7	35.6	44.50	2693.9	488.6	-0.113	0.998	2.05	1.05	2671.1	792.7	0.88	94	14	2
214.93	-1.00	974.3	0.0	44.84	2685.7	488.0	-0.111	0.998	2.07	1.07	2663.7	785.4	0.87	95	14	2

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SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75   PAGE 29

TIME SEC	E-DOT DEG/SEC	V-DOT FT/SEC	H-DOT FT/SEC	R-DOT FT/SEC	W-DOT LBM/SEC	CFNREQ	CFN	SFC LBM/HR/LBF	TT4 DEG R	ISP SEC	V-IDEAL FT/SEC	NMAP	DYN PRESS LBS/FT2
21.06	0.0	-0.0	0.0	1337.4	-21.2	0.57591	0.57591	14.7969	0.0	243.3	1657.0	C	2094.88
21.16	0.0	-0.0	0.0	1337.4	-21.2	0.57590	0.57590	14.7970	0.0	243.3	1659.9	0	2094.88
21.56	0.0	-0.0	0.0	1337.4	-21.2	0.57583	0.57582	14.7972	0.0	243.3	1671.5	0	2094.88
23.16	0.0	-0.0	0.0	1337.4	-21.2	0.57554	0.57554	14.7980	0.0	243.3	1718.2	0	2094.88
29.56	0.0	-0.0	0.0	1337.4	-21.2	0.57443	0.57443	14.8014	0.0	243.2	1907.5	0	2094.87
55.16	0.0	-0.0	0.0	1337.4	-21.0	0.57020	0.57020	14.8141	0.0	243.0	2705.6	0	2094.87
83.66	0.0	-0.0	0.0	1337.4	-20.9	0.56598	0.56598	14.8269	0.0	242.8	3684.2	0	2094.87
102.43	0.0	-0.0	0.0	1337.4	-20.8	0.56348	0.56348	14.8346	0.0	242.7	4391.4	0	2094.86
117.71	0.0	0.0	0.0	1337.4	-20.7	0.56160	0.56160	14.8404	0.0	242.6	5011.3	0	2094.86
133.17	0.0	0.0	0.0	1337.4	-20.7	0.55984	0.55984	14.8459	0.0	242.5	5685.6	0	2094.86
148.74	0.0	-0.0	0.0	1337.4	-20.6	0.55821	0.55821	14.8510	0.0	242.4	6420.7	0	2094.86
162.87	0.0	-0.0	0.0	1337.4	-20.6	0.55685	0.55685	14.8553	0.0	242.3	7145.8	0	2094.86
175.35	0.0	0.0	0.0	1337.4	-20.5	0.55575	0.55575	14.8587	0.0	242.3	7839.1	0	2094.86
186.75	0.0	0.0	0.0	1337.4	-20.5	0.55482	0.55482	14.8617	0.0	242.2	8525.3	0	2094.86
187.82	0.0	0.0	0.0	1337.4	-20.5	0.55474	0.55474	14.8619	0.0	242.2	8592.1	0	2094.86
187.82	-4.086	-53.2	0.0	1337.4	-3.9*********	0.05550	28.5228	0.0	126.2	8592.1	0	2094.86
187.92	-4.078	-52.1	-9.5	1332.1	-3.9*********	0.05594	28.5233	0.0	126.2	8593.3	0	2078.43
188.06	-4.068	-50.7	-23.1	1324.4	-3.9*********	0.05656	28.5258	0.0	126.2	8594.9	0	2055.28
188.06	-0.006	-49.1	-23.1	1319.5	-3.9*********	0.05656	28.5258	0.0	126.2	8594.9	0	2055.28
188.16	0.005	-48.4	-23.1	1319.5	-3.9*********	0.05697	28.5283	0.0	126.2	8596.1	0	2040.33
188.56	0.004	-45.7	-22.7	1300.7	-3.9*********	0.05859	28.5379	0.0	126.1	8600.7	0	1983.14
190.16	0.001	-37.0	-21.5	1235.0	-3.9*********	0.06485	28.5748	0.0	126.0	8619.2	0	1789.67
192.69	-0.003	-27.7	-20.1	1154.2	-3.9*********	0.07399	28.6301	0.0	125.7	8648.5	0	1565.40
195.08	-0.002	-19.8	-19.1	1096.5	-3.9*********	0.08173	28.6796	0.0	125.5	8676.2	0	1414.82
196.42	-0.000	-15.2	-18.7	1073.2	-3.9*********	0.08516	28.7065	0.0	125.4	8691.8	0	1356.44
197.82	-0.000	-11.7	-18.4	1054.5	-3.9*********	0.08807	28.7344	0.0	125.3	8708.2	0	1310.36
201.44	-0.000	-6.3	-17.8	1023.0	-3.9*********	0.09317	28.8046	0.0	125.0	8750.6	0	1235.69
205.25	-0.002	-3.5	-17.5	1004.9	-3.9*********	0.09611	28.8772	0.0	124.7	8795.5	0	1194.81
209.06	-0.007	-3.2	-17.2	992.4	-3.9*********	0.09812	28.9493	0.0	124.4	8840.5	0	1167.41
211.22	-0.003	-3.1	-17.2	985.5	-3.9*********	0.09924	28.9902	0.0	124.2	8866.2	0	1152.62
212.84	-0.001	-3.1	-17.1	980.5	-3.9*********	0.10008	29.0207	0.0	124.0	8885.7	0	1141.77
214.93	-0.000	-3.0	-17.0	974.2	-3.9*********	0.10115	29.0598	0.0	123.9	8910.6	0	1128.22

TRAJECTORY STEP COMPLETE

VII-32

CONFIGURATION   1

RELATIVE COST SUMMARY
(COSTS IN THOUSANDS OF 1974 DOLLARS)

MISSILE DEVELOPMENT COSTS   75921.50
    AIRFRAME + INTEGRATION   22070.53
    PROPULSION SYSTEM   5193.41
    GUIDANCE SYSTEM   17287.19
    CONTROLS SYSTEM   8171.01
    WARHEAD   23199.42
MISSILE FIRST UNIT PRODUCTION COSTS   770.92
    AIRFRAME + INTEGRATION   345.65
    PROPULSION SYSTEM   66.64
    GUIDANCE SYSTEM   252.54
    CONTROLS SYSTEM   103.04
    WARHEAD   3.06
TOTAL COST THROUGH FIRST UNIT PRODUCTION   76692.38

* * * * * * * UNCLASSIFIED * * * * * *

SUMMARY COST DATA PRINTED
IF ICOST=-1 IN THE NAMI LIST

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=2)   CGSM   FEB 75

CONFIGURATION   1
RELATIVE COST BREAKDOWN - DEVELOPMENT
(COSTS IN THOUSANDS OF 1974 DOLLARS)

AIRFRAME + INTEGRATION	22070.53
ENGINEERING	5274.73
DEVELOPMENT	1496.41
FLIGHT TEST OPS.	637.32
TOOLING	4985.28
MFG. LABOR	5162.31
MFG. MATERIALS	1836.99
QUALITY ASSURANCE	671.10
PROFIT	2006.41
PROPULSION SYSTEM	5193.41
GUIDANCE SYSTEM	17287.19
CONTROLS SYSTEM	8171.01
WARHEAD	23199.42
TOTAL	75921.50

RELATIVE COST BREAKDOWN - FIRST UNIT PRODUCTION
(COSTS IN THOUSANDS OF 1974 DOLLARS)

AIRFRAME AND INTEGRATION	345.65
ENGINEERING	47.31
TOOLING	43.48
MFG. LABOR	133.68
MFG. MATERIALS	72.37
QUALITY ASSURANCE	17.38
PROFIT	31.42
GUIDANCE SYSTEM	252.54
CONTROLS SYSTEM	103.04
WARHEAD	3.06
PROPULSION SYSTEM	66.64
EXTERNAL BOOSTER	16.84
CASE	1.25
INSULATION	0.26
NOZZLE	2.13
PROPELLANT	0.40
PROP. LOADING	3.04
IGNITER	0.39
SAFE + ARM	0.19
PROFIT	1.53
SOLID ROCKET SUSTAINER	49.80
CASE	12.68
INSULATION	1.21
NOZZLE	6.41
PROPELLANT	4.19
PROP. LOADING	14.30
IGNITER	0.39
SAFE + ARM	0.19
PROFIT	4.53
INTEGRATION	5.91

VII-34

DETAILED COST DATA
PRINTED IF ICOST=1
IN THE NAM1 LIST

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75

```
CONCEPT * ******
        * 1 * COMP    WT.LB    LT.IN    PHASE    RANGE.NM  ALT.FT  VEL.M
        * ****** **   ***      ***               ***       ***     ***
COST*    770.92  WING   162.            CRUISE    36.7      500.    1.20
WORTH    36.06   TAIL   96.             LLRI      0.0       0.      0.0
CEP      0.01    PLC    1675.   118.    TOTAL     44.8
FORCE    100.    SUST.  5034.  137.
RELIB    0.95    S.PROP    4280.
                 BOOSTER 1033.   75.
                 B.PROP    683.
                 TOTAL  8000.  255.
```

COST SUMMARY

```
           TOTAL      AF+I      PROP      GUID      CONT      W/H
F.U.P.     770.924    345.648   66.636    252.543   103.038   3.059
RCT+E      75921.500  22070.527 5193.414  17287.188 8171.008  23199.422
```

BASIC VARIABLES LIST

```
WING   TAIL  M.A.R  L.P/L  W.W/H  b.G/C  DIAM  B.T/W  F.PARAM  S.ISP  C.PRES  MIX.R  W.OR.L
15.24  7.23  1.00   118.0  1000.  195.   28.0  10.00  10000.   285.0  1500.   1.00   8000.
```

```
WT.MTR   5034.    LT.MTR  137.
WT.PROP  4280.    EXIT.D  6.66
WT.INRT  753.     PWF     0.85
WT.NOZ   62.      MASS.R  0.61
DUAL EXT BOOSTERS
```

MISSILE SUMMARY DATA OUTPUT
DURING CONCEPT GENERATION

VII-35

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75   PAGE 33

```
$NAMSCR
ZIP 11 3 0    0    0    0    0
LEVELS=    10,NCOUT=    24,NLOUT=    10
$END
```

* * * * * UNCLASSIFIED * * * * *

"OUTPUT OF THE 'INPUT' FOR NAMSCR"

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75

CONCEPT	WORTH	COST	LENGTH	RANGE	RCR	RRI	DIAM	WW/H	WEIGHT	VCR
1	36.06	771.	254.8	44.8	36.7	0.0	28.0	1000.	8000.	1.20

SUMMARY LIST OF GENERATED
CONCEPTS (PRIOR TO SCREENING)

V-II-371

SCLIC ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2)   CGSM   FEB 75

```
LEVEL   *******
        *  1  *
        *******

CONCEPT  *  1  *  COMP     WT.LB   LT.IN   PHASE   RANGE.NM  ALT.FT  VEL.M
         *******  ***      ***     ***     ***     ***       ***     ***
COST$  770.92     WING     162.    118.    CRUISE  36.7      500.    1.20
WORTH  36.06      TAIL     96.     137.    LLRI    0.0       0.      0.0
CEP    0.01       PLC      1675.           TOTAL   44.8
FORCE  100.       SUST.    5034.
RELI?  0.95       S.PROP   4280.
                  BOOSTER  1033.   75.
                  B.PROP   683.
                  TOTAL    8000.   255.
```

COST SUMMARY

```
            TOTAL       AF+I       PROP       GUID       CONT       W/H
F.U.P.     770.924    345.648    66.636     252.543    103.038    3.059
RDT+E    75921.500  22070.527  5193.414  17287.188  8171.008  23199.422
```

BASIC VARIABLES LIST

```
WING   TAIL   W.A.R   L.P/L   L.W/H   W.G/C   DIAM   B.T/W   F.PARAM   S.ISP   C.PRES   MIX.R   W.OR.L
15.24  7.23   1.00    118.0   1000.   195.    28.0   10.00   10000.    285.0   1500.    1.00    8000.
```

```
WT.MTR   5034.     LT.MTR   137.
WT.PROP  4280.     EXIT.D   6.66
WT.INRT  753.      PWF      0.85
WT.NOZ   62.       MASS.R   0.61
DUAL EXT BOOSTERS
```

UNCLASSIFIED

MISSILE SUMMARY DATA FOR SCREENED CONCEPTS

VII-38

SOLID ROCKET SSM TEST CASE - SINGLE CONCEPT(IPSM=-2) CGSM FEB 75

SUMMARY FOR LEVEL 1

CONCEPT	WORTH	COST	LENGTH	RANGE	RCR	RRI	DIAM	MW/H	WEIGHT	VCR
1	36.06	771.	254.8	44.8	36.7	0.0	28.0	1000.	8000.	1.20

* * * * * * UNCLASSIFIED * * *

SCREENED CONCEPTS BY LEVEL

SCLIC ROCKET SSM TEST CASE - SINGLE CCNCEPT(IPSM=-2) CESM FEB 75   PAGE 37

UNCLASSIFIED

* * * * * * * * * * * * *

ZIP 1000   0   0   0   0

* * * * * * * * * *

UNCLASSIFIED

SEATIDE

SEATIDE ANALYSIS PROCESS

VOLUME IIIA

CRUISE MISSILE — CONCEPT GENERATION AND SCREENING MODEL (CM-CGSM)

USERS MANUAL

VOUGHT SYSTEMS DIVISION
LTV AEROSPACE CORPORATION
P.O. BOX 5907 · DALLAS, TEXAS 75222